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Royal Canadian Mounted Police National Operations Center Layout Study and Design Options

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ABSTRACT/RÉSUME

The Centre for Security Science (CSS) is a joint endeavour between Defence Research and Development Canada (DRDC) and Public Safety Canada to provide science & technology services support to address national public safety and security objectives (Defence Research and Development Canada, 2010). In June 2010 the former Director of the National Operations Center (Gerry Doucet) requested support from CSS to *"perform a comprehensive review of our national operations centre... maximizing our current centre and also looking at suggestions for a new one"* (17 June 2010). In response to this request CSS contracted CAE Professional Services (CAE PS) to provide expert advice to its customers by applying Human Factors Engineering (HFE) methodology to a wide variety of organizational and functional problems. By identifying the enabling technologies, processes and personnel requirements that are necessary for an organization to achieve its mission, the HFE process will clearly show the most important area of concern for an organization.

The successful approach applied to municipal Emergency Operation Centers (EOCs) was applied for this research into the operations of the National Operations Center (NOC) for the Royal Canadian Mounted Police (RCMP).

Objective

The objective of this research was:

1. To understand the purpose of the NOC and its role in fulfilling the RCMP's mandate;

2. To identify the roles and responsibilities of the NOC personnel and their information exchange requirements;

3. To define a series of HFE requirements and criteria to inform the design effort and provide supporting rationale, and

4. To deliver concepts for the physical layout of the existing NOC to maximize the effectiveness of the NOC's capability for emergency management in the short-term and long-term timeframes. The layout produced during the conduct of the present work provides the foundation for subsequent discussions that will refine the proposed layout into the optimal configuration.

The work conducted as part of this project can be categorized into an Analysis Framework with four phases: data collection, system analysis, requirements definition, and layout design generation. The intent of this document is to summarize the findings stemming from each phase of the work package.

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Le Centre des sciences pour la sécurité (CSS) a été mis sur pied en collaboration avec Recherche et développement pour la défense Canada (RDDC) et Sécurité publique Canada afin de fournir des services et du soutien en matière de sciences et technologie pour appuyer les objectifs nationaux relatifs à la sûreté et à la sécurité publiques (Recherche et développement Canada, 2010). En juin 2010, l'ancien directeur du Centre national des opérations (Gerry Doucet) a demandé le soutien du CSS afin *« d'effectuer un examen complet du Centre national des opérations (...) afin de maximiser le rendement*

de ce dernier et prendre connaissance des suggestions visant un nouveau centre » (17 juin 2012). En réponse à cette demande, les dirigeants du CSS ont conclu un marché avec CAE Services professionnels (CAE SP). Ce dernier offrira des conseils d'expert aux clients en utilisant la méthodologie de l'ingénierie des facteurs humains à un vaste éventail de problèmes organisationnels et fonctionnels. En identifiant les technologies habilitantes, les processus et les besoins en personnel qui sont nécessaires pour que l'organisation remplisse sa mission, le processus d'ingénierie des facteurs humains permettra de montrer clairement le secteur de préoccupation le plus important d'une organisation.

L'approche efficace utilisée pour les centres des opérations d'urgence (COU) a été appliquée dans le cadre de cette recherche sur le Centre national des opérations (CNO) pour la Gendarmerie royale du Canada (GRC).

Objectif

Les objectifs de la recherche étaient :

1. Comprendre la mission du CNO et le rôle qu'il joue pour remplir le mandat de la GRC;

2. Identifier les rôles et responsabilités du personnel du CNO et les besoins en matière d'échange d'information;

3. Définir une série d'exigences liées à l'ingénierie des facteurs humains et les critères pour orienter la conception et fournir une justification à l'appui;

4. Élaborer des concepts en vue de l'aménagement physique du CNO existant afin de maximiser l'efficacité de sa capacité de gestion des urgences à court et à long terme. L'aménagement conçu dans le cadre du travail actuel fournit le fondement des discussions à venir qui permettront de peaufiner l'aménagement proposé en vue d'obtenir la configuration optimale.

Les travaux menés dans le cadre de ce projet peuvent être classées dans un cadre d'analyse en quatre phases: la collecte des données, l'analyse du système, la définition des besoins, et la génération de schéma de configuration. Le but de ce document est de résumer les conclusions découlant de chaque phase du programme de travail.

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1 Introduction

1.1 Background

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1.1 Context

The Centre for Security Science (CSS) is a joint endeavour between Defence Research and Development Canada (DRDC) and Public Safety Canada to provide science & technology services support to address national public safety and security objectives (Defence Research and Development Canada, 2010). In June 2010 the former Director of the National Operations Center (Gerry Doucet) requested support from CSS to *"perform a comprehensive review of our national operations centre... maximizing our current centre and also looking at suggestions for a new one"* (17 June 2010). In response to this request CSS contracted CAE Professional Services (CAE PS) to provide expert advice to its customers by applying Human Factors Engineering (HFE) methodology to a wide variety of organizational and functional problems. By identifying the enabling technologies, processes and personnel requirements that are necessary for an organization to achieve its mission, the HFE process will clearly show the most important area of concern for an organization.

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1. To understand the purpose of the NOC and its role in fulfilling the RCMP's mandate;

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3. To define a series of HFE requirements and criteria to inform the design effort and provide supporting rationale, and

4. To deliver concepts for the physical layout of the existing NOC to maximize the effectiveness of the NOC's capability for emergency management in the short-term and long-term timeframes. The layout produced during the conduct of the present work provides the foundation for subsequent discussions that will refine the proposed layout into the optimal configuration.

The work conducted as part of this project can be categorized into an Analysis Framework with four phases: data collection, system analysis, requirements definition, and layout design generation. The intent of this document is to summarize the findings stemming from each phase of the work package.

2 Methodology

2.1 General

The RCMP NOC design must satisfy the requirements for all federally mandated responsibilities held by this organizational entity. To satisfy this objective, CAE PS employed a HFE approach that is built upon a user-centered design process. The People-Environment-Task (PET) framework underpins this process by characterizing the information and interactions between:

1. Users and their characteristics (e.g., anthropometry, biomechanics, physiology, perception, cognition, education, training, attitudes);

2. Scenario-based tasks and the required level of performance (e.g., speed, accuracy, frequency, duration, compatibility, complexity); and,

3. Environment, both physical and organizational, and the impact on the users' ability to perform their tasks within it.

As such, the user-centered approach focuses on the users' abilities and real needs, context, work, goals, and tasks. The approach also looks at the domain of work in which individuals are engaged and how they interact with computers. This ensures that all designs are traceable back to an analysis of operator tasks, and that user reviews are based on task-based reviews of these critical tasks.

The following subsections provide the detailed description of the analysis framework as well as the methodology that was ultimately employed and approved by the client.

2.2 Data Collection

Visits, observations and interviews were conducted by CAE PS to gather sufficient information to inform the definition of goals, processes, connectivity, and organizations associated with the NOC. Interviews focused on the working level with representation from all levels within the organization. An attempt was made to interview the full range of individuals responsible for the different areas of interest within the NOC. The interviews, notes and observations in the report provided the background for the modelling and simulation development efforts.

2.3 System Analysis

2.3.1 Mission Analysis

A Mission Analysis was performed to articulate the roles, missions, organization, personnel, equipment and other relevant information associated with the definition and layout of the NOC. In this respect, the Mission Analysis was an essential prerequisite for conducting the subsequent HFE analysis activities including the identification and analysis of goals and tasks. Furthermore, the Mission Analysis set out the boundaries of the subsequent analyses in terms of the scenarios, the crews (and their likely

characteristics), the anticipated system functions and features, and the likely environments within which the NOC will operate.

Findings stemming from the Mission Analysis are presented in Section 3.1.

2.3.2 Goal/Function Analysis

The Goal/Function Analysis identified a set of goals in a hierarchical format that defines the objectives (i.e., what needs to be achieved) of the RCMP NOC. Development of the RCMP NOC goal hierarchy leveraged the Hierarchical Goal Analysis (HGA) methodology. The HGA aspires to provide a high level focus on objectives, desired end states, rather than actions. To that end, it does not aim to specify the processes, resources, and systems by which the NOC organization accomplishes the goals. This is the objective of subsequent analysis efforts (i.e., task analysis) that articulate the processes, resources, and systems by which these goals are being (or could be) achieved (i.e., what and how). As such, direct links can be established between the hierarchy of goals from HGA and the subsequent process and operational connectivity models.

The RCMP NOC goal hierarchy and goal descriptions are detailed in Section 3.2.

2.3.3 Task Analysis

Tasks are defined as perceptual, cognitive or manual behaviours that are required of an individual to achieve a particular goal or function. The primary objective of a Task Analysis was to develop requirements to support the definition of a potential layout for the NOC. This is accomplished by creating a database of task-related information to support the analysis of the existing system. This information is beneficial to various other activities including system design and specification, user evaluations, system acceptance, and training development.

The Task Analysis provides an understanding of the current means (i.e., people, technology, processes) by which the previously defined goals are achieved by the NOC. The tasks for each of the individual roles as part of these three phases of a response (Activation, Operational, Demobilization) are described in comprehensive checklists documented in Appendices 1 and 2 of the NOC Operations Procedure Plan (National Operations Center, 2008). These checklists address the objectives of the Task Analysis activities as it pertains to the HFE design effort for the existing NOC. To that end, the HFE team referred to these existing checklists as required to augment the analysis findings.

2.3.4 Architecture Framework Analysis

The next portion of the system analysis focused on the development of a series of architecture framework products, based on the data gathered during previous HFE activities, in accordance with the Department of National Defence Architecture Framework (DNDAF). Only those products deemed necessary to support the generation of layout requirements were included as part of this analytical effort.

2.3.4.1   Information Exchange/Communication Links/Physical Links

To ensure that the layout of the NOC satisfies the collaboration, communication, and situation awareness requirements, the following information was captured:

1. **Link Tables.** These specialized data tables will identify the visual and verbal communication requirements between all key individuals within the NOC;

2. **Visibility and reach requirements.** These requirements are focussed on the criteria that must be met for individuals to perform the necessary tasks using the systems and peripheral equipment (e.g., large screen displays); and

3. **Interactions.** The interactions that occur between the RCMP NOC and external organizations and entities will be captured.

Information dependencies internal and external to the RCMP NOC were depicted through a series of Operational Node Connectivity Description (OV-2) drawings. An OV-2 depicts significant operational nodes and "needlines" (i.e., dependencies associated with the exchange of the information). The OV-2 is an essential tool in articulating operational concepts; it identifies key nodes and the interactions required to conduct operational activities. This artefact also reflected the dependencies that are introduced as a result of the added capabilities that are under consideration by the RCMP.

The analysis results pertaining to the Information Exchange, Communication Links, and Physical Links are presented in Section 3.3

2.3.4.2   Organizational Relationships

The organizational relationships and various Command and Control characteristics to facilitate organizational response were depicted through an Organizational Relationships Chart (OV-4). This artefact clarifies the various relationships that can exist between organizations and sub-organizations within the NOC as well as between the NOC and external organizations.

The NOC organizational relationship are depicted in Section 3.1.3.

2.3.4.3   Temporal Sequence of Tasks

The development of Task Flow Diagrams (TFDs) for all goals relevant to the design effort illustrate graphically the logical and chronological relationships between the various mission goals as well as illustrating the processes, personnel and systems by which goals can be achieved. Data captured as part of this task not only informed the design for the layout of the RCMP NOC but also helped to define roles and responsibilities associated with the individuals and the capabilities that were under consideration by the RCMP NOC.

Similar to the Task Analysis activities, task information was leveraged as required from the existing operator checklists documented in the NOC Emergency Operations Procedure Plan (National Operations Center, 2008).

2.3.4.4   System Interfaces

The System View (SV-1) architecture data product describes systems and networks as well as the interconnections providing for, or supporting, the RCMP NOC functions. In turn, constraints dealing with the connectivity between systems were identified thereby leading to the definition of potential solutions.

A listing of systems and their organizational connectivity is provided in Section 3.4.

2.3.5 Design Layout Requirements

Based on results stemming from the Analysis Phase, a series of design requirements were created. The objective was to ensure that the requirements provide discrete direction to inform the layout of the RCMP NOC as well as the criteria for assessing design options. These design requirements were validated though discussion with the appropriate stakeholders.

Upon validation of the design requirements, the existing layout of the RCMP NOC was assessed against these criteria.   Current bottlenecks and shortcomings that impact the effectiveness in the ability of the RCMP NOC to achieve the goals were then articulated.

Layout design requirements and the evaluation of the current NOC layout against these criteria are presented in Section 4.

2.3.6 2D Operations Room Layout Options

The original approach documented in the SOW was to create a series of low fidelity prototypes of the layout options in the form of 2D drawings using Microsoft Visio. The intent was to create the options in a manner that is both quick and cost effective while providing a sufficient level of accuracy to support their objective assessment. Since the Computer-Aided Design (CAD) drawings were initially available to the HFE team, higher fidelity 3D representations of layout options could be developed with relative ease and therefore were utilized as the preferred medium for visualizing and assessing layout options.

2.3.7 3D Ops Room Layout Options

A 3-D model of the NOC was developed within the modelling environment to facilitate both visualization and anthropometric assessment. Fully rendered models, including auxiliary equipment, were made available within a user-controlled application structure to facilitate free movement within the modelled space, to support the review process. The model was developed as required to ensure it incorporated the requisite elements to evaluate the associated layout criteria.

As a means to performing a comparative analysis of the individual layouts, a Link Analysis was used to analyze the auditory and visual communication links for each of the options.   This analysis was performed for each key individual taking into consideration all the previously identified communication and interaction links. Visual and auditory links based on importance levels (high, medium and low) for all operator interactions were evaluated in terms of:

1. The distance between the information sender and receiver was appropriate for effective visual and auditory communication;

2. The orientation between operators or an operator and his/her equipment was appropriate for effective interaction; and,

3. The presence of communication distractions or interruptions (e.g., distracting other operators or blocking an operator-equipment interaction).

In addition to the Link Analysis, an anthropometric assessment was conducted using HumanCAD, and a series of mannequins to represent the effective physical range of the anticipated user population (e.g., 5th percentile female to 95th percentile male). A series of reach, vision and clearance tests, corresponding to the task-based scenario, was used to evaluate the proposed layout. These tests were used to determine if the anticipated user population could perform the defined tasks that are under consideration by the RCMP NOC. The mannequins were exercised within the 3-D model of the RCMP NOC. Issues associated with reach, vision and clearance were documented for resolution.

Through consultation with the appropriate stakeholders, modifications to the layout were made to resolve, to the extent possible, those aspects which failed the anthropometric assessment. Tests were repeated, as necessary, to determine the success/failure of the modifications.

Section 5 documents the design efforts including the approach taken, options explored, and the anthropometric assessment effort.

3 System Analysis

The system analysis effort was comprised of the following inter-related analyses:

1. Mission analysis;

2. Goal analysis;

3. Task analysis;

4. Information exchange;

5. Organizational relationships; and

6. System interfaces.

The collective findings stemming from these analyses were employed to generate the NOC layout requirements presented in the subsequent section. The following sections summarize the results from the system analysis effort.

3.1 Mission Analysis Findings

The output from the Mission Analysis documented the roles and missions of the NOC as well as provided a brief description of the current layout focusing on their missions, crew composition, and pertinent systems (e.g., communication).

3.1.1 Responsibilities

In accordance with doctrine, the NOC's mandate is "to gather and process the information required to support strategic-level decision-making, and to strategically coordinate and/or manage the RCMP's National-level response to national security, natural, technological failures and/or cyber events" (National Operations Center, 2008). NOC operations personnel provide the necessary manpower and processes to facilitate day-to-day NOC activities as well as to provide support functions to assist with an activation of the NOC. When additional resources are required to manage emerging, imminent or occurring events, a Crisis Management Team (CMT) is mobilized. The CMT consists of pre-designed/trained personnel from the relevant HQ Sector and subject matter experts from other RCMP HQ sectors.

The NOC has responsibility for the following emergency management functions (National Operations Center, 2008):

1. Monitor, assess and report round-the-clock on emerging, imminent or occurring all-hazard events;

5. Enable and enhance decision-making for senior management direction by communicating up to date information;

6. Develop NOC Action Response Plans and coordinate the strategic response one or two simultaneous incidents;

7. Coordinate the management of strategic-level information and resources (human and physical);

8. Establish and maintain communications/information exchange with the Government of Canada (GOC) and OGD emergency operations centers, and where appropriate with Non-Government Organizations (NGO) and private sector emergency operations centers;

9. Establish and maintain communications/information exchange with Division Emergency Operations Centers (DEOCs), coordinating/managing as required responses between regions and divisions; and

10. Process military assistance requests from the divisions and seek approval from the Commissioner.

These responsibilities are described in greater detail as part of the Goal/Function Analysis in Section 3.2.

3.1.2 Utilization

The NOC facility is employed by the RCMP for the following purposes:

1. **Major Events/Crisis.** Activation of the NOC may be in response to planned Major Event such as the Vancouver Olympics. Similarly, the NOC will be activated to provide assistance as required for an unplanned crisis.

2. **Operations/Investigations.** The NOC provides a secure environment, including communication and information systems, for supporting and/or monitoring various major case management or law enforcement operations. Typically, a Joint Intelligence Group will be occupying the NOC for performance of these activities. Use of the NOC for this purpose is a result its security designation thereby providing a suitable environment to conduct classified discussions and process classified materials.

3. **Training.** Occupation of the NOC may take place to support training exercises in order to ensure an appropriate level of readiness on behalf of the NOC and its personnel.

3.1.3 Organizational Structure

As per the NOC Emergency Operations Procedure Plan (National Operations Center, 2008), a fully mobilized NOC operation is comprised of the roles within the organizational structure as presented in Figure 1. The left side of the organizational structure (i.e., NOC Director and supporting personnel) supports the NOC day-to-day operations and infrastructure whereas the right side is staffed as per the Incident Command System (ICS) structure to respond to incidents.
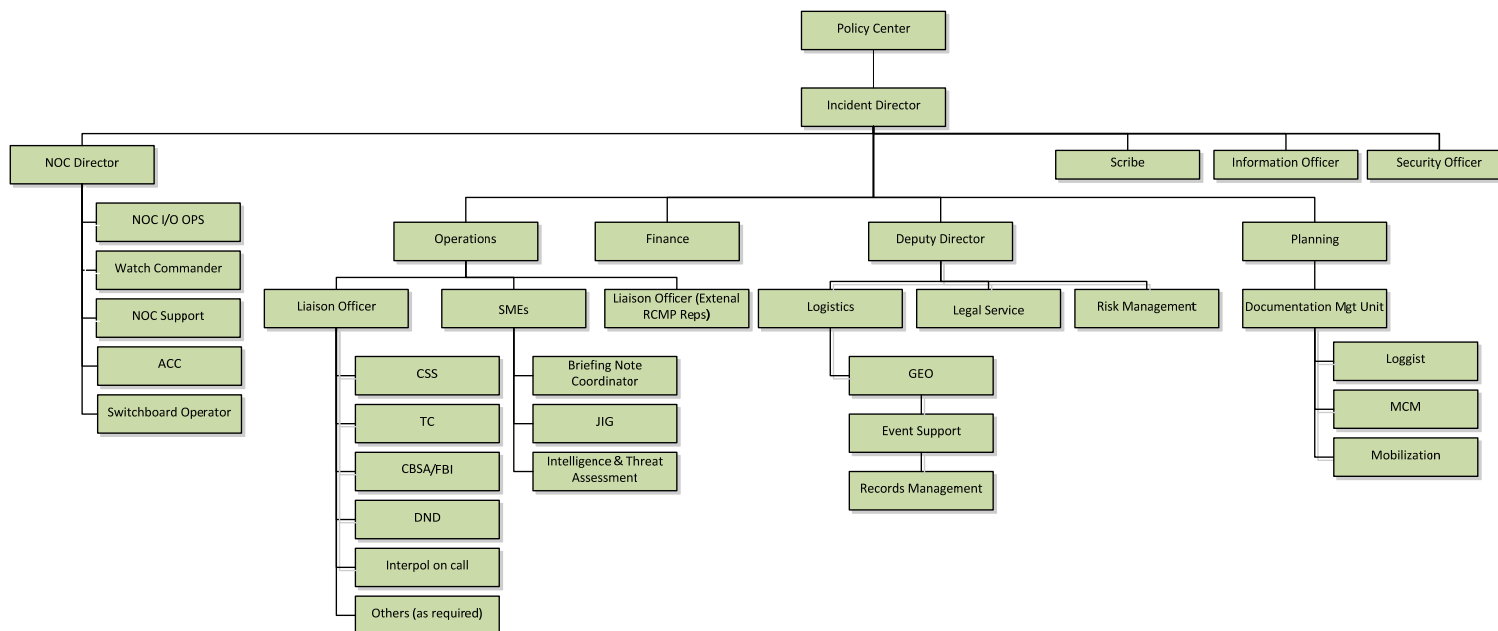
Figure 1: NOC Organizational Relationships Chart (OV-4)

In accordance with NOC documentation (National Operations Center, 2008), the roles and responsibilities of the primary groups are as follows:

1. **NOC Incident Director and Command Staff** includes the following primary people:

a. Incident Director exercises overall management responsibility for the coordination of the support to the emergency response

b. Deputy Incident Director ensures the efficient and effective flow of information within the NOC. Ensure resource requests are prioritized and tracked.

c. Scribe is responsible for all note taking and data entry of actions taken or initiated by the NOC Incident Director.

2. **Operations** is responsible for the coordination of all response activities. The Operations Section Chief directs the preparation of the response plan as well as requests or releases resources. The operations staff is comprised of:

a. Liaison Officers that coordinate with agencies external to the RCMP and act as the point of contact for outside personnel to the NOC; and

◆ Subject Matter Experts (SME) who are the technical and operational experts providing advice to the Incident Director. The selection of SMEs is contingent on the nature of the event.

3. **Planning** is responsible for information management, preparing situation reports, displaying situation information, maintaining a status of resources and developing a response plan. Included in the Planning Section is the Loggist who is responsible for logging and filing all documentation.

4. **Logistics** is responsible for providing all services and support to meet all the needs of the event.

5. **Finance** is responsible for all financial and cost analysis aspects as they pertain to the response. This includes all event costs and any administrative activities not handled by other functions.

6. **Policy Group** includes the NOC Incident Director who receives national policy guidance and direction from the Policy Group which may consist of the Commissioner/DCOI, applicable Deputies and A/Commrs, and/or designated executive level staff;

In addition to the NOC organizational structure depicted above, a Joint Intelligence Group (JIG) may also occupy the NOC in order to take advantage of the secure environment to conduct on-going investigations. The JIG is an integrated intelligence collection and analysis group that provides intelligence and threat assessments to the appropriate stakeholders. Their outputs (e.g., SITREPs and analytical reports) are employed by their stakeholders for planning and operational purposes. The roles and responsibilities of the JIG are distinctly different than the aforementioned ICS roles. Furthermore, the original intent of the NOC did not envision usage of the NOC by a JIG; however, the proposed layout options will investigate the ability to accommodate collaborations of this nature while not comprising the primary intent of the NOC to provide the infrastructure to react to major events and crises.

3.1.4 Response Levels

As per the NOC Emergency Operations Procedure Plan (National Operations Center, 2008), the three response (or activation) levels for the NOC are as follows:

1. **Level One – Normal Response.** Continuously operating at this level, NOC personnel provide an initial

response in accordance with standard operating procedures and established plans. This includes:

a. Identification of the nature of the event;

b. Initial event assessment;

c. Issuance of notification, if warranted; and

d. Determination of further response options (no further action is required, continued monitoring only required, or initiating Level Two or Three response).

Manning of the NOC for Level One is limited to Administrative Communications Center (ACC) personnel (two civilians) and two RCMP Duty Officers.

11.**Level Two – Standby.** The Incident Director in consultation with the NOC Director will selectively augment NOC personnel with additional CMT resources (e.g., Incident Commander, Scribe, SMEs, etc.) in order to:

a. Initiate the appropriate response planning process; and

b. Coordinate internal and external readiness activities as part of planning, or response coordination.

2. **Level Three – Full Response**. For this level, the NOC is fully staffed by the Incident Director and CMT in order to address the events including an act of terrorism, major airliner crash, and mass casualty event. Most notably, an information/file management capability is stood up as part of the Planning Unit in order to establish a robust protocol for handling incoming and outgoing messages.

3.1.5 Current Layout

The current floor plan for the RCMP NOC is depicted in Figure 2. The primary unit spaces within the secure portion of the NOC are the Operations Area, Air Cell and ACC[1]. While the layout of theses rooms will be adapted to better equip the NOC personnel for achieving their goals and objectives, the segregation of the NOC into these three areas will remain intact.

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[1] The space adjacent to the air cell was configured as a temporary workspace with cubicles. Utilization of this area by personnel was on an ad-hoc basis.
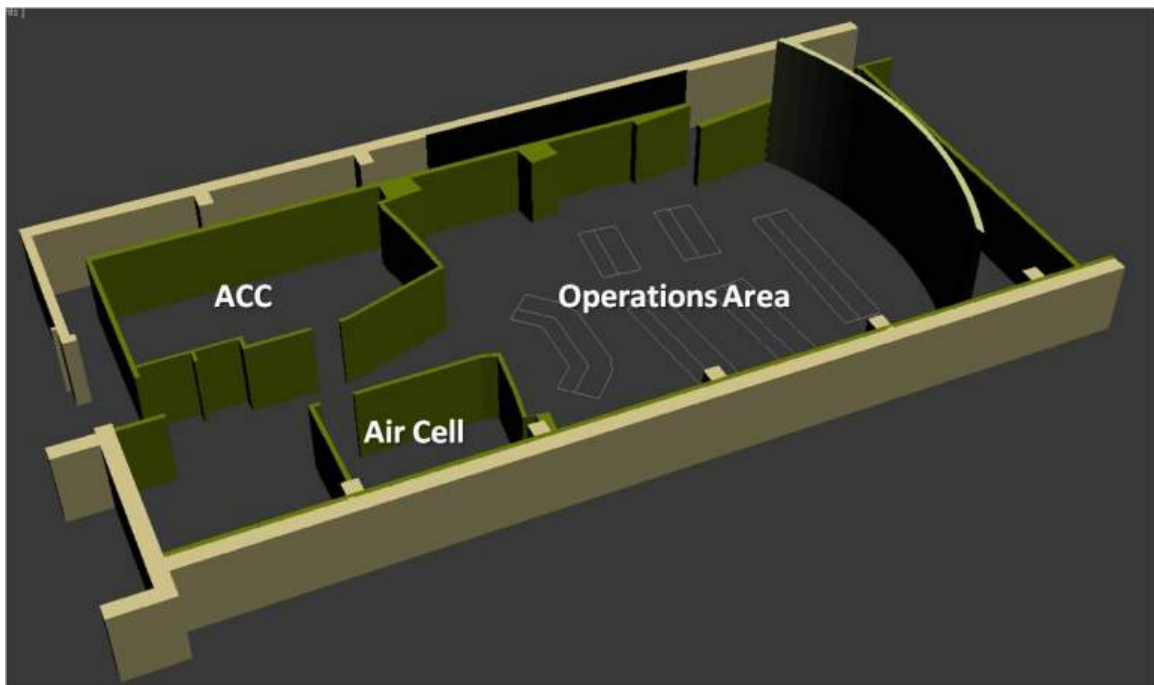
Figure 2: National Operations Center Floor Plan

3.1.5.1   Operations Area

The Operations Area provides the infrastructure for the day-to-day operations of the NOC as well as the ability to support a surge capability as a result of activating a CMT in response to an imminent or current event. Due to this secure designation of the NOC, this area may also be employed by a JIG to conduct an on-going investigation or operation dealing with sensitive information.

Figure 3: Current Operations Area Layout

The layout of the Operations Area is as follows:

1. **Data entry row** consists of five workstations to be employed by individuals to perform data entry tasks. These workstations were installed at a later date in order to accommodate individuals performing these tasks. While visual access to the information wall above their heads is not ideal, these roles are not critical to an incident response and therefore do not require visual access to the information presented on these large screens.

2. **Liaison Officer (LO) row** comprises seven workstations to accommodate the LOs from organizations external to RCMP including Department of National Defence (DND), Transport Canada (TC), Canadian Security Intelligence Service (CSIS), and Canada Border Services Agency (CBSA). These workstations provide access to systems specific to the agency.

3. **Analyst row** includes four workstations for individuals to perform analytical duties as required to support incident responses.

4. **Information Management row** comprises four workstations for the roles of File Coordinator, Information Management, and Data Entry (x2).

5. **The bridge** provides accommodations for two DO to work simultaneous in close proximity to one another. All systems as well as communication devices necessary for the WOs to execute their duties are integrated into the bridge.

6. **Command pod** provides collaborative arrangement for the Incident Commander, Deputy Incident Commander and Scribe workstations. These individuals are responsible for directing the team in their response effort.

7. **Media pod** is reserved for the Media Information Officer and Analyst.

The Operations Area is equipped with the following primary technological capabilities:

a. Desktop computers with access to RCMP systems (i.e., RCMP Office Support System (ROSS) and RCMP Classified Environment (CE)) as well as access to LO systems

b. Information wall (4 screens at front)

c. Large screen displays (side walls)

d. Printers (CE, ROSS, Mandrake)

e. Phones

f. Access to security cameras on the hill

g. UPS protection and backup generator power

3.1.5.2   Air Cell

The unit space for the Air Cell (Figure 4) is a separate room within the NOC, adjacent to the operations room, where key decision-makers within the department assemble and manage an air crisis. Given the speed at which these types of events unfold, the NOC is responsible for tactically handling an event.

Figure 4: Current Air Cell Layout

The Air Cell can accommodate upwards of approximately eight individuals for tactically responding to an air incident. This team is typically comprised of the following roles: Commander accompanied by a Scribe, Deputy Commander and Aid, Canadian Forces Aerospace Command Component (CFACC) representative, CF LO, Loggist, and Consequence Management. The ACC is equipped with the following technological capabilities:

h. Desktop computer with access to Flight Explorer and Consolidated Secret Network Infrastructure (CSNI)

i. 52" High Definition television & interactive touchscreen

j. Whiteboard walls

k. TV streams

l. Teleconference phone lines (e.g., CFACC, Universal Data Link Control (UDLC))

3.1.5.3   Administrative Communications Centre

The ACC houses access to and operation of telecommunications systems and a secure facsimile capability (Figure 5). These transmission systems are essential to the management of national and international emergency situations and for maintaining situation awareness.
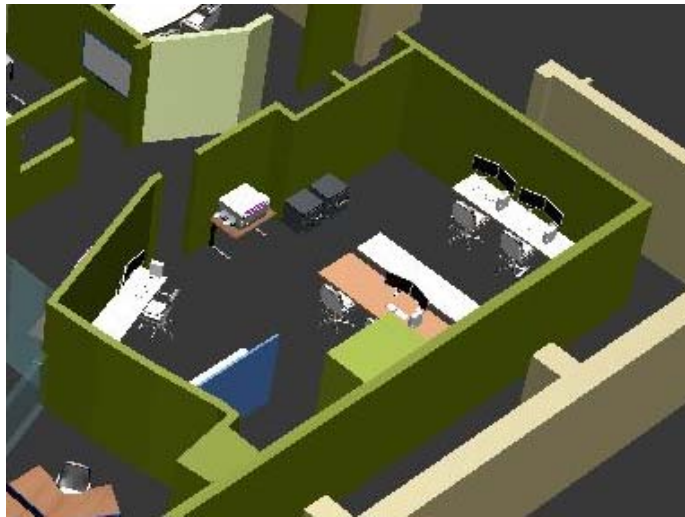
Figure 5: Current ACC Layout

3.1.5.4   Support Unit Spaces

In addition to the three primary unit spaces within the secure area, the NOC is also comprised of the following support unit spaces: These unit spaces are described herein for the purpose of completeness; however, the layout of these spaces was not assessed as part of the current analysis and design effort.

1. An entrance space that includes a lobby and reception area as well as office space to accommodate the personnel responsible for the day-to-day NOC operations (i.e., NOC Director and support personnel).

2. An executive-style boardroom is equipped with projectors to facilitate presentations as well as a videoconferencing capability to communicate with external participants. Visual access to the operations area is also provided from this room so that visitors can witness this unit space without disrupting the personnel on the floor.

3. Support facilities such as washrooms with showers, break-out rooms, and a kitchenette are provided in close proximity to the secure area. These facilities not only support the standard day-to-day activities but also provide the infrastructure in the event of a long term presence by personnel in the NOC to address a specific incident.

4. Mechanical and electrical rooms to house the associated equipment (e.g., heating, ventilation and air-conditioning (HVAC) units, electrical panels) for controlling environmental factors such as thermal, air quality, lighting, and acoustics.

3.2 Goal Analysis

3.2.1 General

The goal hierarchy identified the goals that must be achieved in order to satisfy the mission objectives. Successive decomposition of goals involves a decomposition of the missions from top-level goals down to third-level goals. The decomposition yielded an inventory of goals in a nested order which captures the parent and related child goals. That is, following each top-level goal, all related first-level goals were listed, and between each first-level goals, all the second-level goals associated with the first-level goals were listed, and so on. The decomposition continues down to the most basic goals – defined as a goal that cannot be decomposed further and is the responsibility of a   single (person or small group) operator.

3.2.2 Goal Inventory

Figure 4 1 presents the top three levels of the NOC goal hierarchy as defined through review of documentation and feedback from the interviews with NOC personnel.   This inventory illustrates the hierarchical relationship between child and parent goals.

3.2.3 Goal Descriptions

The following sections provide a textual description of each of the top- and first-level goals.

3.2.3.1   Strategic Level Administration and Operations are Coordinated and Commanded

The mandate of the NOC is to provide strategic level Command and Control (C2) support to the regions in the event of an incident. Execution of C2 at the tactical level from the NOC is reserved to responding to air incidents whereby the RCMP acts as the lead agency and provides direction to other supporting agencies.
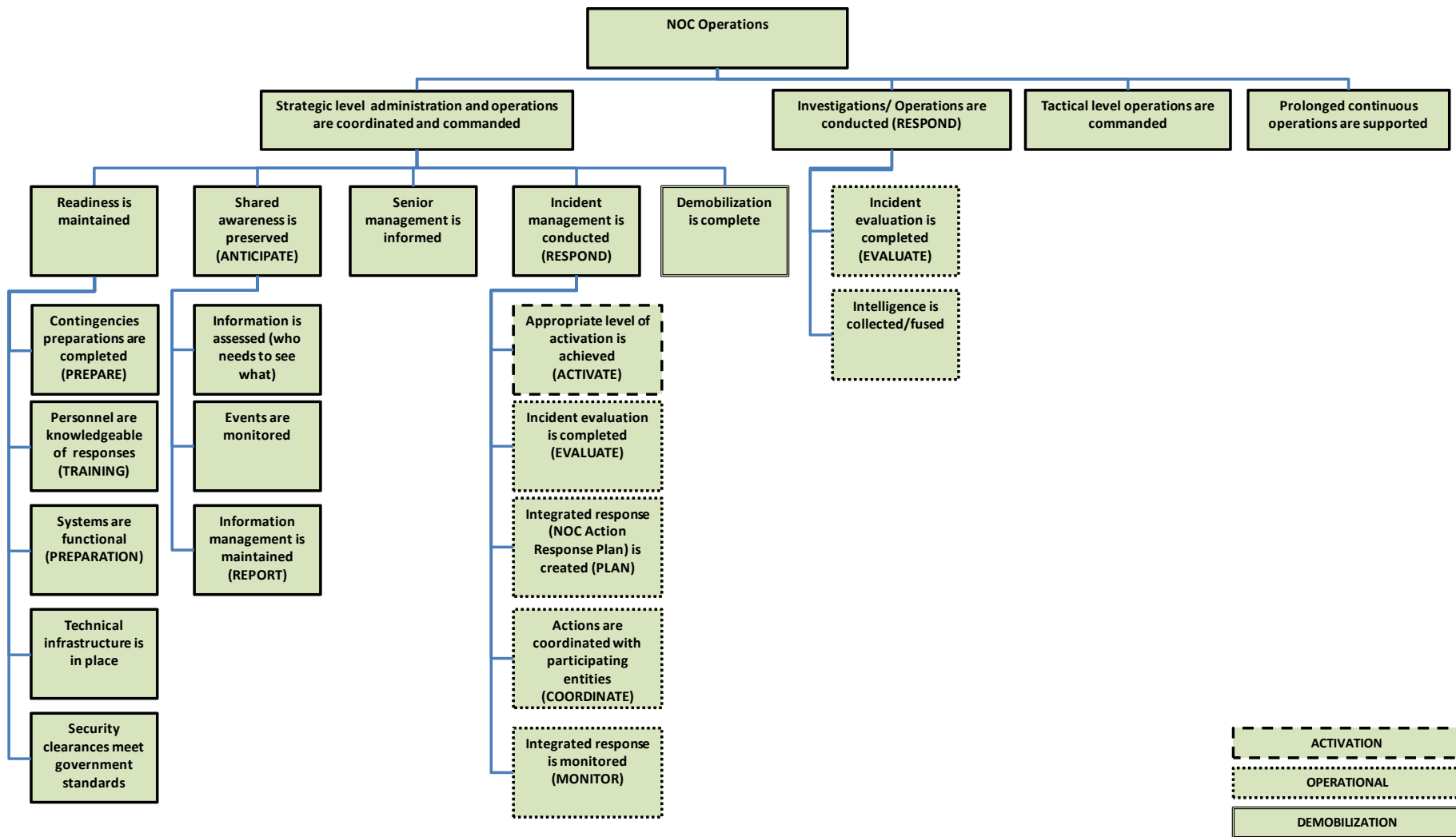
Figure 6: RCMP National Operations Center Goals

3.2.3.1.1 Readiness is maintained

This goal represents the routine, non-emergency daily monitoring operations performed by the NOC. The routine consists of reading daily situation awareness products published within RCMP and Other Government Departments (OGDs), and ensuring that the appropriate members of the RCMP Senior Management and Executive teams are made aware of events or upcoming events that could fall under the jurisdiction of the RCMP.

As part of ensuring readiness, the following sub-goals were identified:

1. **Contingencies preparations are completed.** The proper procedures and related precautions must be in place as a means to address future incidents should they arise;

2. **Personnel are knowledgeable of responses.** Training needs to occur in order to ensure that personnel are able to effectively execute the necessary tasks to address the incident;

3. **Systems are functional.** Systems must be routinely checked to ensure proper functioning as a means to maintain an appropriate level of readiness to handle an incident. This includes ensuring that all of the software is up-to-date from a security standpoint;

4. **Technical Infrastructure is in place.** The NOC provides space for LOs from external departments and agencies (e.g., DND, TC, CSIS, CBSA) to work in the Operations room in order to support the response to a specific incident. To that end, the RCMP must ensure that that in addition to the physical working space, the proper connectivity to the external systems must be provided and maintained; and,

5. **Security Clearances meet Government Standards**. Since the NOC requires handling of classified materials, personnel, equipment and facilities must all satisfy the minimum standards set forth by the Government of Canada. Maintaining these standards allows the NOC to host external agencies (e.g., Federal Bureau of Investigation) to support on-going investigations and operations. As per the NOC Emergency Operations Procedure Plan (National Operations Center, 2008), all personnel deployed at the NOC must hold a current TOP SECRET security clearance with CSE Indoctrination – Level III.

3.2.3.1.2 Shared Awareness is Preserved

Establishing a sense of shared awareness involves 1) individually comprehending the meaning of the situation at hand and 2) establishing a common understanding of the situation across the team. While understanding the situation is a cognitive activity, the sharing of information to establish shared awareness is a business process involving data collection, collation, interpretation, and distribution. Subject matter experts evaluate and integrate information inputs and progressively build a broader and deeper recognized "Common Operating Picture" (COP). This has become an increasingly important function with dedicated staff that remains on "watch" to maintain a COP to support Command decisions. The analytical summations generated to support subordinate geographic, component and/or functional Commanders are fused to provide the broader perspective that superior Commanders require.

The RCMP NOC is accountable for events within their jurisdiction as well as ensuring the security and safety of the individuals under their responsibility. To that end, the RCMP NOC maintains a response level of Level One – Normal Readiness. Level 1 is effectively the daily vigilance in the monitoring phase of operations. This is not to suggest that monitoring is not critical to the operations of the RCMP; it serves the vital role of providing decision makers with sufficient information make informed decisions, and pass necessary information to stakeholders as appropriate.

1. **Events are Monitored.** In order for the decision-makers to manage the response to a given event, the CMT needs to be collectively aware of the current   status of the event. This involves scanning the

environment and collecting information. Information of this nature will be obtained through sources external to the NOC such as other government departments, news feeds, and the DEOCs. In turn, all incoming information must be disseminated to the NOC personnel for subsequent assessment;

2. **Information is Assessed.** Information presented to the NOC personnel must be placed in context, synthesized, and utilized to generate a mental image of the circumstances in order to identify and evaluate potential responses, if necessary. Situation awareness of this nature provides the backdrop for conceiving and assessing any necessary courses of action; and,

3. **Information Management is Maintained.** An important function of the NOC is the collection, collation, processing and subsequent dissemination of information.

3.2.3.1.3 Senior Management is Informed

Senior management must be continually updated with on-going events in order to provide them with the information necessary to make decisions. Updates are provided through such means as phone, e-mail, and daily briefs. For example, daily updates are provided through briefs at 0800 and 1030.

3.2.3.1.4 Incident Management is Conducted

An event or incident can be viewed as an unplanned, non-recurring occurrence that impacts normal day-to-day activities. The distinction between these two types of events lies in the scale and scope of the response. Notably both are discrete occurrences with a start and an end that mandate a response from the Integrated Security Unit (ISU). Events can be relatively benign occurrences (in the larger scheme of Olympic security), such as a heart attack in the stands, minor assaults, pick pocketing; typically incidents are more significant occurrences, such as a fire at a venue, an angry crowd gathering, a hostage taking or an unauthorized air intrusion.

The NOC is responsible for coordinating a response to events that fall under their jurisdiction. To that end, the NOC relies on the ICS framework as a structured approach to meet this objective. As part of strategically responding to the incident, the following sub-goals were identified:

4. **Appropriate Level of Activation is Achieved.** Once a decision has been made to activate the NOC, all members of the CMT staff must be contacted and notified in order to mobilize the NOC to the appropriate level of response;

5. **Incident Evaluation is Completed.** An initial evaluation of the triggering incident must be completed in order to assess its scope and criticality;

6. **Integrated Response is Created.** Each incident is evaluated with the appropriate responses generated and coordinated by the NOC;

7. **Actions are Coordinated with Participating Entities.** Coordination of security and public safety depends on an exchange of relevant information between participating entities. Security concerns may require control of information; however, an integrated effort is required for emergency management in response to an incident; and,

1. **Integrated Response is Monitored.** The response to the incident must be continually monitored to assess its effectiveness in managing the incident consequences. Continual appraisal of the response also ensures that the CMT can adapt as a means to address any unforeseen dynamics.

3.2.3.1.5 Demobilization is Complete

Once the incident has been accordingly addressed and upon receiving authorization from the NOC Incident Director, assigned positions will be de-activated. This involves such activities as completing all required forms, reports, and other documentation; participating in formal post-operational briefs, and submitting your notebook to the Documentation Management Unit.

3.2.3.2   Investigations and Operations are conducted

While not originally envisioned as a use for the NOC, special interest groups (e.g., JIG) utilize this secure facility as a means to perform on-going investigations and operations. To that end, investigation teams comprising of RCMP personnel as well as the necessary LOs congregate in the NOC in order to collect, analyse, fuse, and produce intelligence products for subsequent presentation to senior management. Collaborations of the nature provide a 'Whole of Government' approach to address the current investigation/operation.

3.2.3.3   Tactical Level Operations are Commanded

The Air Operations Cell operates within the Air Cell unit space and is responsible for handling air incidents. To that end, the NOC personnel, specifically the Air Operations Commander, assume tactical command of the airborne incident. An airborne incident could be triggered by a small aircraft not squawking the proper codes to air traffic control thereby resulting in the non-responsive aircraft being tagged as a Contact of Interest (COI). In response, the NOC Air Operations Cell monitors the COI while trying to gather as much intelligence and information related to specific passengers, crew or flights. As required, the NOC will be in constant communications with DND personnel in the event that military air resources must be deployed to support resolution of the incident. Utilization of regional RCMP resources, if necessary, to assist with the response will also be coordinated by the NOC.

3.2.3.4   Prolonged Continuous Operations are Supported

In the event that personnel are required to work for extended hours for a prolonged period of time, the NOC is equipped with a support infrastructure in the form of sleeping accommodations, sanitary facilities (e.g., showers, locker room) and kitchen facilities.

3.3 Information Exchange

Information dependencies internal and external to the RCMP NOC were depicted through a series of Operational Node Connectivity Description (OV-2) drawings coupled with a Link Analysis Table to identify the visual and verbal communication requirements between all operational positions in the Ops Room. An OV-2 depicts significant operational nodes and "needlines" (i.e., dependencies associated with the exchange of the information).

3.3.1 Internal to NOC

To support the design and validation of the layout for the NOC Operations Area, an OV-2 (Figure 7) was generated to visually depict the communication connectivity between the NOC personnel within the secure area within the context of incident response. To that end, the following conclusions can be made:

1. There are several sub-groups (e.g., Command, Operations, Planning, Logistics) that collaborate and communicate on a frequent basis. These groupings align with the organizational hierarchy depicted in Figure 1; and,

2. The Command functional grouping requires communication linkages with each of the unit chiefs (Operations, Planning, and Logistics) as well as the Information Officer.

As a supplement the OV-2 for the internal communications, a Link Analysis Table (

Table 1) was created to further describe the importance of all visual and auditory links between the personnel in this unit space (i.e., between a 'sender' and a 'receiver'). The Link Analysis Table comprises ratings (i.e., high, medium and low) for the importance (defined as the priority and frequency of communication) for the following communication types:

1. **Auditory**. Unassisted hearing or speaking with an operator; and,

2. **Visual**. Viewing an operator.
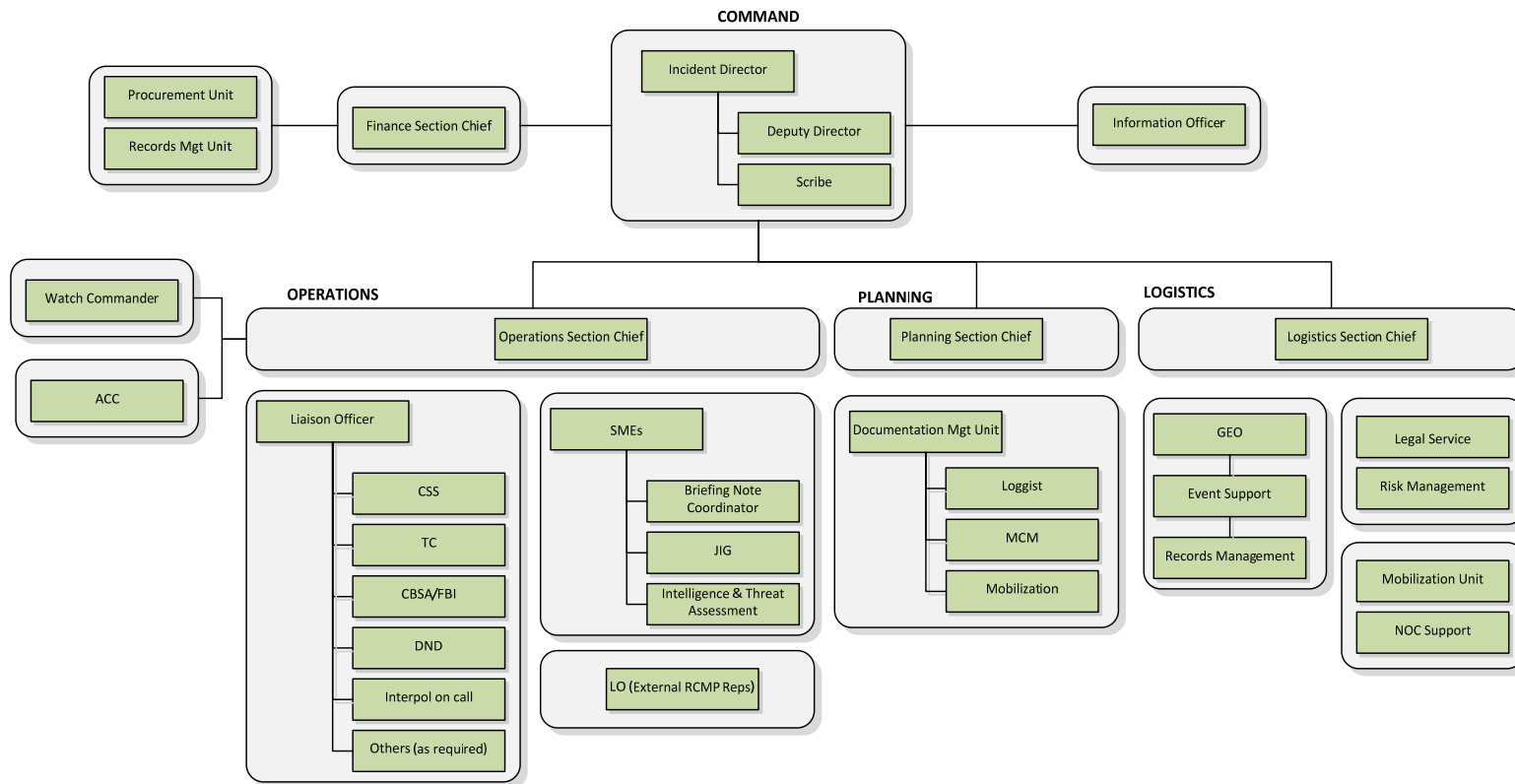
Figure 7: NOC Internal Operational Connectivity (OV-2)

Table 1: Visual and Auditory Communication Links

	ID		Deputy Dir		Scribe		Ops Sect Chief		LOs		SMEs		Plan Sect Chief		Doc Mgt Unit		Loggist
	A	V	A	V	A	V	A	V	A	V	A	V	A	V	A	V	A
Incident Director			H	H	H	H	H	H	-	-	-	-	H	H	-	-	-
Deputy Director	H	H			L	L	H	H	-	-	-	-	H	H	-	-	-
Scribe	H	H	L	L			-	-	-	-	-	-	-	-	-	-	-
Operations Sect Chief	H	H	H	H	-	-			H	H	H	H	M	M	-	-	-
Liaison Officer	-	-	-	-	-	-	H	H			H	H	-	-	-	-	-
SMEs	-	-	-	-	-	-	H	H	H	H			-	-	-	-	-
Planning Sect Chief	H	H	H	H	-	-	M	M	-	-	-	-			H	H	H
Doc. Mgt Unit	-	-	-	-	-	-	-	-	-	-	-	-	H	H			H
Loggist	-	-	-	-	-	-	-	-	-	-	-	-	H	H	H	H	
MCM	-	-	-	-	-	-	-	-	-	-	-	-	H	H	H	H	H
Finance	M	M	-	-	-	-	-	-	-	-	-	-	H	H	H	H	H
Logistics Sect Chief	M	M	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
Legal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GEO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Event Support	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Record Mgt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Risk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Information Officer	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3.3.2 External to NOC

Operational connectivity between the NOC and external agencies is illustrated in the OV-2 architecture date product below (Figure 8). Of note, the NOC will maintain continual collaboration with DEOCs, other EOCs, and the GOC as required to address the requirements pertaining to the incident in question. Furthermore, external communications with US and/or international law enforcement agencies may take place on an 'as needed' basis. Within the RCMP, issues that cannot be resolved based on the authority delegated to the Incident Director may be pushed on the RCMP command hierarchy (i.e., Deputy Commissioner, Commissioner, Minister) in order to seek the necessary approval authority. Conversely, the command authority is passed through the same hierarchy as the conduit to provide the NOC with the necessary command direction to perform its duties. Similar to the relationships at the working level, the RCMP command structure collaborates with their external counterparts as required to resolve issues within their sphere of authority.
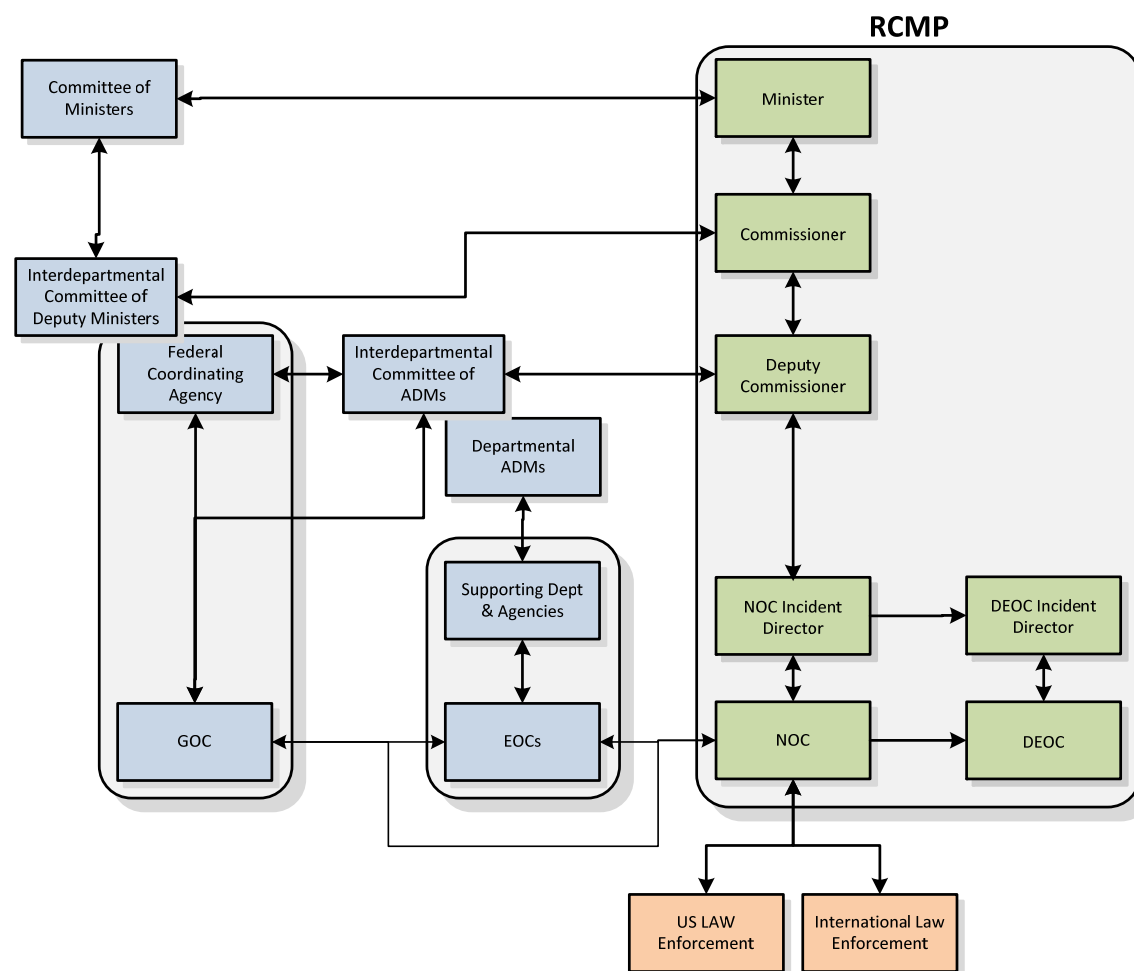
Figure 8: NOC External Operational Connectivity (OV-2)

3.4 System interfaces

The System View (SV-1) architecture data product describes systems and networks as well as the interconnections providing for, or supporting, the RCMP NOC functions.

Within the RCMP organization, the primary networks for sharing and dissemination of information are ROSS for unclassified materials and RCMP CE for classified. External to the RCMP organization, the NOC collaborates with a myriad of agencies and departments, most notably DND, CSIS, TC, DFAIT, and CBSA. Interoperability with these agencies is typically facilitated via the LO seated within the NOC using the networks detailed below.

1. Department of National Defence:

a. Defence Wide Area Network (DWAN) provides distributed access to classified material up to Protected B.

◆ Consolidate Secret Network Infrastructure (CSNI) is the primary CF Command System, operating in a SECRET domain. It provides all operational units, worldwide, with essential desktop automation (MS Word, PowerPoint, Access and Excel) plus web connectivity and an electronic mail capability. TITAN operates in a DEDICATED mode of operation at the Secret Secure – (CAN/US) level. Accessible via TITAN are the Maritime Command Operational Information System (MCOIN) and the Air Force Command and Control Information System (AFCCIS) in support of the CF Navy and Air Force, respectively.

◆ RELCAN Network provides NORAD input to the CF's Recognized Air Picture.

2. Government of Canada:

a. MANDRAKE II is the Secret system that assists the dissemination of information at all levels of classification

3. Department of Foreign Affairs and International Trade (DFAIT)

a. SIGNET C5 is the DFAIT network used primarily for secure text processing and secure messaging. Sources include Canadian missions abroad, and OGDs (i.e., DND, DFAIT) and recipients include Privy Council Office (PCO) and Prime Minister's Office (PMO), OGDs, and missions abroad.

In addition to the aforementioned networks providing interoperability with external agencies, the RCMP NOC interacts with external agencies via secure faxes, video conferencing, and both secure and non-secure telephone lines.

4   RCMP NOC Design Layout Requirements

4.1 General

Data collected from interviews with the various roles within the NOC and gleaned from RCMP documentation coupled with HFE design guidance for Emergency Operation Center layouts led to the development of a series of requirements pertaining to the design of the NOC facility. The intent of these requirements is not to prescribe a specific layout but rather to ensure that the end design satisfies the NOC objectives while complying with HFE Best Practices. Further, the potential layout produced during the conduct of the present work is intended to provide the foundation for subsequent discussions that will refine the proposed layout into the optimal configuration.

Requirements have been divided into the groupings listed below. While the sustainability and survivability groupings do not directly impact the floor plan layout, they do influence the overall design of the NOC facility and therefore have been included herein for completeness. These requirements require validation from the Subject Matter Experts to ensure their overall reliability.

1. Collaboration/Teamwork;
2. Situation Awareness;
3. Taskwork;
4. Flexibility;
5. Security;
6. Interoperability;
7. Sustainability;
8. Survivability; and
9. Environment.

Given the objectives of this study, only those requirements that specifically impact the physical placement of equipment within the NOC were considered throughout the design phase of the effort.

The following sections present the requirements for each of the functional groupings with the associated sources for derivation of the individual criteria. Sources for the individual requirements are as follows:

1. **UFC**: United Facilities Criteria (Department of Defense, 2008);

2. **ISO 11064**: Ergonomic Design of Control Centers (International Organization for Standardization, 2000);

3. **CSA**: Canadian Standards Association International Guidelines for Office Ergonomics (Canadian Standard Association International, 2003):

4. **NOC:** Data collected through interviews and NOC documentation;

5. **MIL-STD-1472**: Design Criteria Standards – Human Engineering (Department of Defence, 1999);

6. **MIL-HDBK-759**: Handbook for Engineering Design Guidelines (Department of Defence, 1995); and

7. **Stanton**: Human Factors in the Design and Evaluation of Central Control Room Operations (Stanton, Salmon, Jenkins, & Walker, 2010).

4.2 Collaboration/Teamwork

Facilitating teamwork and collaboration are crucial pieces to ensuring the overall effectiveness of the team within the NOC. Teamwork is about working toward a shared goal. In order to achieve this objective, the individual team members must coordinate their work with other team members, so that the relevant information is shared. Coordination (i.e., mutual adjustments between team members) is a central feature of teamwork. Coordination can be viewed as an activity in itself, as a necessary overhead when several individuals are contributing to the performance of a collective task. Coordination involves ensuring that the right tasks happen at the right time by the right operators. Coordination of actions becomes cumbersome without assuming a vast amount of shared operation or common ground. Coordination is achieved using a combination of communication and monitoring (Brannick & Prince, 1997):

1. **Communication.** Communication is a major component of teamwork and is the process by which information relevant to the task and strategies are shared among the different stakeholders in an organization. Communication helps to establish a common understanding of the task engaged which in turn supports collaboration and coordination. This understanding may be established through explicit or implicit means of distributing information within and between team members. Communication is the teamwork component that links the other components (Dickinson & McIntyre, 1997). Communication is the link between monitoring other team members' performance and providing feedback about that performance (McIntyre, Salas, Morgan, & Glickman, 1989); and

2. **Monitoring.** Monitoring refers to the observation of activities of other team members (Dickinson & McIntyre, 1997, p. 22). This implies that individuals, before they can be part of a team, must have the knowledge and skills to perform their individual tasks and have an understanding of the tasks of other team members (Cooper, Shiflett, Korotin, & Fleishman, 1984; Larson & LaFasto, 1989). Monitoring team performance is a crucial component of teamwork (Cooper, Shiflett, Korotin, & Fleishman, 1984; McIntyre, Salas, Morgan, & Glickman, 1989; Dickinson & McIntyre, 1997, pp. 21-22).

The following requirements are aimed at ensuring that the layout of the NOC supports collaboration and teamwork amongst the NOC team members.

Table 2: Collaboration/Teamwork Requirements

	Collaboration/Teamwork Requirements	SOURCE
	Communication and Sightlines	
	Support verbal communication links between select personnel in accordance with Table 1. Locate individuals requiring frequent interaction with each other in close proximity.	NOC, Stanton
	Allow social contact by grouping operators so that informal conversations can occur between individuals without compromising operator efficiency.	ISO 11064

	Collaboration/Teamwork Requirements	SOURCE
	Provide the ability to support group discussions with all co-located members (e.g., SITREP).	UFC, NOC
	Support distributed collaboration between NOC team members that are geographically distributed.	
	Ensure that communications extraneous to the primary functions of NOC personnel do not distract personnel.	Stanton
	Arrange operational areas for maximum efficiency in exchange of information and social interaction between areas.	ISO 11064, UFC, Stanton
	Optimize operational links, including sightlines,	Stanton
	Minimize interference between operational areas and support areas.	UFC, NOC
	Prevent individuals from sitting within each other's "intimate zones" when grouping workstations. Working positions adopted for extended periods should avoid operators having to intrude within each other's intimate zones.	ISO 11064
	Provide ability to receive warning of all relevant emergencies.	UFC
	Provide ability to receive emergency notification and protective action recommendations regarding a CSEPP chemical event by a communications facility staffed around the clock through direct, reliable, and redundant communications with the on-post notification point.	UFC
	Provide direct, 100% reliable, and redundant communications with the on-post EOC from both the primary and alternate off-post EOCs,	UFC
	Provide capability for high-speed exchange of hard copy with the on-post EOC via computer or telephone facsimile,	UFC
	Provide adequate communications links with public evacuation vehicles and their dispatch agencies.	UFC
	Minimize noise due to ringing telephones	UFC
	Provide hands free communications.	

Collaboration/Teamwork Requirements	SOURCE
Subgroup discussions	
Physically separate rooms and locations with different functions/operational areas to minimize potential sources of disturbance.	Stanton
Provide the means for multiple sub-groups to collaborate while minimizing interference with others. Sub-groups include: Emergency Management Committee, Planning, Operations, and Security	NOC
Provide a conference room where senior staff can collaborate. m. The conference room should have a large meeting table with stations for 10-12 staff. n. Provide voice, data, and power outlets for each station for telephones and computer connections. o. Provide a minimum of three large electronic displays—one for news, one for briefings and one for command operations—visible to all participants. p. Maximize wall space in meeting rooms to facilitate additional, flat panel displays, erasable marker boards and maps	UFC, NOC
Provide additional conference and meetings places for breakout meetings and briefings. Arrange these places to allow different sub-groups to conduct breakout conference sessions away from the primary activity in the operations rooms. q. Size the meeting rooms to accommodate 4-8 individuals. r. Equip rooms with flexible furniture that can be reconfigured between conference arrangement and individual work tables. s. Equip rooms with multiple data and telephone connection points to allow staff to plug in and work within different configurations.	UFC, NOC
Entrance, Exits, and Passageways	
Allow for the orderly evacuation of the room. Ensure passageways provide adequate clearance	ISO 11064
Corridor widths should be designed with consideration for peak traffic load expected, direction of traffic flow, and number and size of entrances and exits in the area. To allow people to move without restriction, the minimum widths given in Figure 36 should be observed.	MIL-HDBK-795
Space to enable supervision of the entrance(s) should be taken into account	NOC

Collaboration/Teamwork Requirements	SOURCE
Position workstations such that views of entrances and exits are minimized, to reduce visual distraction, from the normal operating position unless operational requirements demand this.	ISO 11064
Adequate provision should be made for the general circulation, such that operations are not interrupted by either visual or auditory distraction.	ISO 11064

4.3 Situation Awareness

Team Situation Awareness (TSA) plays a critical role in military team decision-making. TSA is more than simply aggregating the situation awareness (SA) of individual team members (Schwartz, 1990). For example, Endsley, 1995 argues that whereas individual SA relies mostly on cognitive processes (i.e., perception, comprehension, and projection) TSA involves unique activities, such as coordination and information sharing. Prince and Salas (1993) argue that each team member must seek and communicate information from both the internal (e.g., intelligence center) and external (e.g., outside world) environments. By communicating relevant situation information, team members demonstrate knowledge of their overall mission goals and their individual task responsibilities. Furthermore, they assert that this information exchange among team members contributes to coordinated activity on the part of the team. Wellens (1993) defines TSA as "the sharing of a common perspective between two or more individuals regarding current environmental events, their meaning, and projected future status" (p. 272). He suggests that group SA could be maximized by having each member monitor different segments of the environment with enough overlap among members to ensure opportunities for coordination. Endsley (1995) suggests that TSA consists of both the situation awareness required of each team member and the overlap in SA that is necessary among team members, particularly for coordination. It is the "degree to which every crew member possesses the SA required for his or her responsibilities" (p. 39). Endsley's concept of TSA is an add-on to her more established and formal concept definition of SA. She describes TSA consisting of the individual SA for each team member, plus the SA for potentially overlapping tasks (Endsley, 1995).

Although each of the definitions and descriptions of TSA differs somewhat from the others, they all contain terms that refer to individual SA and teams associated with team processes. Thus, TSA involves two critical abstractions: individual SA and team processes (i.e. teamwork behaviours and cognitive processes that facilitate team performance).

To provide a basis for building TSA, team members need to have information that will help each individual develop relevant expectations about the entire team task. Team SA depends on communication at several levels (Bolman, 1979; Prince and Salas, 1989, 1993; Schwartz, 1990). The process of perceiving environmental information is affected by expectations developed from the communication of knowledge about mission objectives, own tasks, other relevant tasks, team capabilities, and other factors associated with team performance (Bolman, 1979; Prince and Salas, 1989, 1993). Then, as information is integrated and comprehended, interpretations provided by other crew members may affect that comprehension. Thus, as new information is perceived from the environment by individual team members and is collected and shared (Bolman, 1979), the situation awareness of other team members may be modified accordingly.

The following requirements are aimed at ensuring of situation awareness information to the individual that the layout of the NOC supports the presentation team members. The intent of these requirements is

direct the placement of shared visual displays for facilitating TSA and not to prescribe the information to be presented on these screens.

Table 3: Situation Awareness Requirements

	Situation Awareness Requirements	Source
	Provide a shared display presenting a common operating picture (e.g., geographical representation of the incident).	UFC, NOC
	Provide a visual representation of individuals holding the specific roles as part of the response	PCO
	Provide status and situation boards (e.g., incident timeline and planning priorities) permitting immediate visual access to information by all EOT members.	UFC, NOC
	Provide TV and commercial radio receivers for monitoring news reports and emergency announcements,	UFC, NOC
	Where the information on a shared large screen display needs to be regularly used by operators, the design of the visual display and the layout of the room should ensure that all of the information which needs to be used by an operator can be seen from the normal working position for both the vertical and horizontal planes	ISO 11064
	Necessary information presented on shared large screen displays shall be visible by personnel, with applicable 5th to 95th percentile body dimensions of the user population, from their normal working positions.	ISO 11064
	Operational information presented on the lowest part of an off-workstation visual display shall be visible to a 5th percentile, seated, non-upright control room operator.	ISO 11064
	Artificial room lighting should not interfere with the visibility of any sections of the shared large screen displays.	ISO 11064

4.4 Taskwork

In addition to supporting the requirements for teamwork and collaboration, the layout of the NOC as well as the design of the workstations need to provide the ability for each team member to perform their individual taskwork. In many cases the workstations will be common across NOC personnel; however, in some instances the workstation will need to be tailored to satisfy the unique roles, responsibilities, and needs of a particular individual (e.g., WO). Moreover, the workstations must be adjustable to satisfy a reasonable anthropometric range of individuals that may be seated at the particular location.
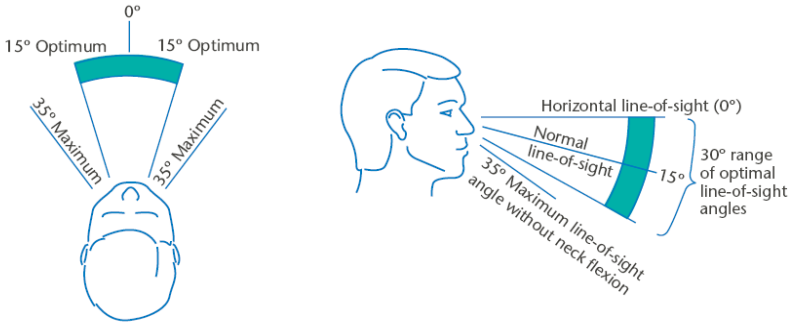
The following requirements are aimed at ensuring that the layout of the NOC supports collaboration and
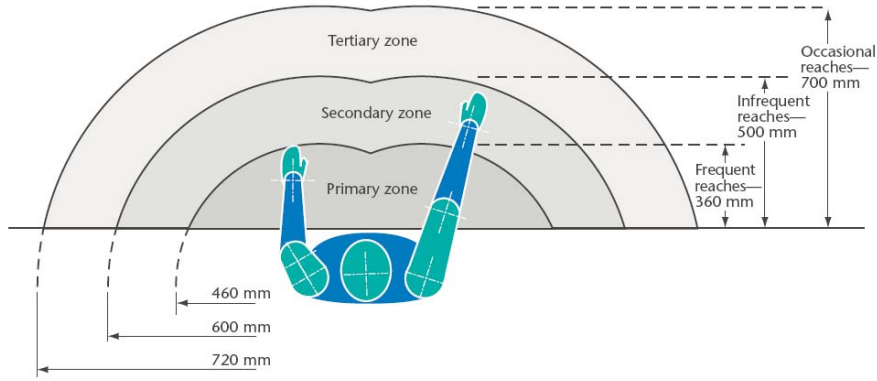
teamwork amongst the NOC team members.

Table 4: Taskwork Requirements

	Taskwork Requirements	Source
	Provide NOC members with individual consoles, as required, to conduct taskwork.	NOC
	Equip consoles with necessary ancillaries to complete taskwork as defined by the Operator Checklists in the NOC Emergency Operations Procedure Plan (National Operations Center, 2008). This includes monitors, input devices, communication devices, task lighting, working surface, storage space, and network accesses.	NOC
Workstation Design		

Taskwork Requirements	Source
Design workstations to accommodate the anticipated range of intended user population (e.g., 5th percentile female to the 95th percentile male). As such, provide the ability to easily adjust the following to accommodate the range in operator sizes: t. Worksurface height u. Keyboard and mouse height v. Seat height w. Viewing distance and display height For example, monitors should be adjustable to raise, lower, move forward and back as well as tilt to allow a comfortable and neutral neck posture for the operator. To minimize neck flexion and possible fatigue, the viewing area of all monitors displaying primary information should be located within ±15° of the normal line of sight. To minimize twisting the neck to either side, the primary display(s) should be positioned within 35° to either side of forward. If operators are required to view a monitor positioned beyond 35°, it is recommended that the operator swivel his or her chair to face the monitor as opposed to frequently twisting the neck. The horizontal and vertical lines of sight are presented in Figure 9. *Figure 9: Line of Sight Angles*	CSA, ISO 11064, MIL-STD-1472, MIL-HDBK-795
Make available sufficient desktop space for placement of reference materials.	ISO 11064, NOC
Provide reference storage shelves at desk height at each console for quick access to information sources by staff.	ISO 11064
Minimize the total height of the console to allow NOC personnel to view large wall displays and to communicate with team members while assuming their primary work posture (e.g., seated, standing).	ISO 11064

Taskwork Requirements	Source
Enough separation is desired to allow staff to concentrate on their particular issues while keeping their material from encroaching on other team member spaces.	ISO 11064
Provide adequate provision for the storage of items of a personal nature (e.g., briefcases, purses), both in the Operations Area while seated at the console or outside this area.	ISO 11064
Locate equipment that is used on a frequent basis or equipment that is required to accomplish critical tasks in the operators primary reach zone. The secondary reach zone is dedicated to tasks which are of lower priority and are performed on an infrequent basis. The tertiary zone is typically used for reference manuals or documents that only require very infrequent use. Figure 10 illustrates the reach dimensions for the primary, secondary and tertiary reach zones. *Figure 10: Reach Guidelines*	CSA
Incorporate an accessible chase integral with the console for equipment and cabling. The chase should allow for access from the front and back sides, so the equipment can be serviced during emergency situations with minimal interruption of the NOC personnel. Vertical chase and grommet holes are required for routing of cabling between equipment.	ISO 11064

4.5 Flexibility

Flexibility in the layout of the NOC aims at ensuring that the operational space is adaptable in order to accommodate the scale of the operation and subsequent response (i.e., Level 1 through 3). This involves having sufficient space, equipment, furniture, administrative supplies, telecommunications, computer support, etc., available to satisfy mission requirements.

The following requirements are aimed at ensuring that the layout of the NOC is flexible (as possible given the constraints) to address varying scales of operations/responses.

Table 5: Flexibility Requirements

	Flexibility Requirements	Source
	Provide flexibility in console design to support different individuals utilizing the workstation for different purposes (i.e., operations, investigations, unplanned and planned events).	NOC
	Provide flexibility in the layout to support teams of varying sizes in their ability to collaborate to accommodate different response levels (i.e., surge capability).	UFC, PCO
	When possible, furniture and equipment should be moveable to allow reconfiguration of the space and conversion of space functions to suit the situation and staff level required for the specific incident. When flexible layouts are used, layout information should be posted and response staff trained on how to quickly implement the appropriate layout.	ISO 11064
	Ensure workstation layouts provide an operationally satisfactory working environment under both maximum and minimum staffing levels.	ISO 11064
	The requirements of secondary users who sometimes need to work in the operations center on a temporary basis should be considered. This can sometimes involve the provision of suitable worktops to lay out paperwork, appropriate seating and accommodation for personal artefacts. All such requirements should be fully determined by the conduct of an appropriate task analysis.	ISO 11064

4.6 Security

From a security perspective, the design of the NOC facility must guard against potential risks and protect operations from the unauthorized disclosure of sensitive information. As such, sufficient security and structural integrity must be in place to protect the facility, its occupants, and communications equipment and systems from relevant threats, hazards, and security breaches.

The following requirements are aimed at ensuring that the layout of the NOC adopts the appropriate security precautions to support classified and unclassified work activities.

Table 6: Security Requirements

	Security Requirements	Source
	Compartmentalize information from sub-teams or individuals due to security restrictions.	NOC
	Store secure documentation with ability to retrieve as required.	UFC

Security Requirements	Source
Provide secure communications capabilities.	NOC
Support ability to conduct classified discussions without risk of being overheard by others.	NOC
Restrict access of personnel to the facilities (controlled access).	NOC
Provide alternate passageways to allow individuals to access areas without interfering individuals working in the operational area.	NOC

4.7 Interoperability

Share common principles of operations and exchange routine and time-sensitive information with other EOCs (e.g., able to communicate with local government EOCs, emergency response teams at or near an incident site, provincial EOC).

The following requirements are aimed at ensuring that the layout of the NOC satisfies the interoperability requirements.

Table 7: Interoperability Requirements

Interoperability Requirements	Source
Provide ability to exchange information (verbal and data) with external agencies as depicted in Figure 8.	NOC
Provide direct communications, that can be reliably maintained under emergency conditions, with the DEOCs, other EOCs, public shelters, state emergency services, etc.	UFC
Provide direct and reliable two-way communications with police, fire, rescue, health, engineering, and other operating units with emergency response functions.	UFC

4.8 Sustainability

Designing sustainability into the NOC facility helps to support operations for extended duration. This includes the ability to sustain operations for a continuous period of extended time during all emergency situations without interruption. To the greatest extent practical, the location of the NOC should be in a place that is not a high-risk area for known hazards such as flood zone, other natural hazards, nuclear power plant, hazardous material sites, train derailments, etc.

The following requirements are aimed at ensuring that the layout of the NOC can maintain continuous

operations over an extended period of time.

Table 8: Sustainability Requirements

	Sustainability Requirements	Source
	Support areas should provide sleeping accommodations adequate for a percentage of total assigned staff at a time	NOC
	Support areas should provide food services (e.g., kitchen)	NOC
	Support areas should provide sanitary facilities (e.g., toilets, showers, laundry, garbage disposal)	NOC
	Provide a minimum of interference between operating and support areas such as eating, sleeping, mechanical equipment and sanitary facilities.	NOC
	Locate all spaces that directly support that function during an emergency incident adjacent to the operations room.	NOC

4.9 Survivability

Survivability of the NOC facility deals with the ability of the Operations Center to keep functioning even after an emergency incident directly affects the facility.

The following requirements are aimed at ensuring that the NOC facility as a whole can survive the direct impact of an incident.

Table 9: Survivability Requirements

	Survivability Requirements	Source
	The EOC and the building in which it is located should, if practicable, have sufficient structural integrity to ensure survivability and operability during a wide range of emergency events.	NOC
	Continued functioning of the EOC during a chemical agent event should be ensured by providing for protection of the staff from toxic agents.	ISO 11064
	Provide an uninterruptible power supply in order to ensure continued power for sustained operations.	NOC

4.10   Environment

The environment, both physical and organizational,   will impact the users' ability to perform their tasks

within it. Environmental factors of interest to the design of the NOC facility include thermal, air quality, lighting, and acoustics.

The following requirements are aimed at ensuring that the infrastructure for the NOC facility provides an appropriate environment for the operators to effectively perform their tasks.

Table 10: Environmental Requirements

	Environmental Requirements	Source
	Thermal	
	Localised heat in control rooms due to thermal radiation or hot air should be avoided by suitable control of the climatic conditions.	ISO 11064
	HVAC systems shall provide appropriate internal climatic environmental conditions (i.e. air temperature, humidity and air velocity), whatever the external thermal conditions.	ISO 11064
	Provide operators with appropriate equipment for controlling and monitoring the temperature in cases where the HVAC systems do not provide suitable internal climatic environmental conditions.	ISO 11064
	Air Quality	
	Allow airflows to be controlled such that personnel do not suffer direct air draughts.	ISO 11064
	Design air conditioning/air handling systems so as to avoid vibration and minimize noise from the system.	ISO 11064
	The rate of air change (i.e. the relation between the capacity of the HVAC system and the physical volume of the control centre) shall be adjusted in order to maintain good air quality.	ISO 11064
	Lighting	
	Lighting arrangements should be appropriate to the visual demands of the tasks to be carried out in the working environment and should take into account the demands of normal and emergency work as well as the effects of artificial and natural light.	ISO 11064
	Ensure operator-controlled task lighting is not a source of glare to other occupants in the room.	ISO 11064
	Provide operators with some control of the local maintained luminance associated with their workstation.	ISO 11064

Environmental Requirements	Source
Employ lighting schemes that avoid veiling reflections and reflected glare off screens.	ISO 11064
Avoid glare irrespective of its source, for example from luminaries, reflections and excessive differences in luminance in the visual field.	ISO 11064
Acoustics	
In order to optimize the acoustic environment, the control room should be designed to reduce noise levels in the general environment around the control room, reduce sound levels within the control room, and reduce reverberation times.	ISO 11064
Acoustic design should take account of the following operational needs: x. verbal communications between operators; y. telephone conversations; z. hearing alarms; aa. performance decrements; bb. interference with cognitive functions, e.g. domestic radios; cc. minimising operator annoyance, e.g. noise from canteens; dd. the loss of essential auditory information.	ISO 11064
The effect of voice communications within the control room arising from, for example, visitors, social discussions and maintenance teams, should be taken into account.	ISO 11064

4.11   Assessment of Current NOC Layout

The existing layout for the NOC was assessed for compliance against a subset of the aforementioned HFE layout requirements. The objective was to highlight those areas of improvement that could be potentially addressed as part of the re-design effort. To that end, the assessment was performed by the CAE PS team with consideration of feedback received from the operational community and primarily limited to those requirements that could be managed through modifications to the layout of the NOC (i.e., collaboration/teamwork, situation awareness, taskwork, flexibility, security). However, issues outside the remit of the layout re-design effort (e.g., process and technology) that were identified as part of this assessment have been documented herein for completeness.

From a high level perspective, the current layout of the NOC provides the fundamental infrastructure to support the organizational objectives as defined in Section 3. Specifically, the layout exhibits the following advantages:

1. **Functional segregation.** The compartmentalization of the Operation Area, ACC, and Air Cell into separate unit spaces provides the ability for the primary functional groupings to perform their collective tasks without impacting (or being impacted by) others. For example, tactical coordination and management of an air incident can be facilitated using the Air Cell since the room provides both a private space for the team to collaborate that is removed from the Operations Area and access to the necessary communication equipment (e.g., phone line to CFACC) and C2 infrastructure (e.g., CSNI workstation).

2. **Team pod configuration**. The arrangement of functional groupings into the pods on the Operations Area floor places the smaller teams into close proximity thereby facilitating communication and collaboration. Although, the layout and design of the consoles could be further optimized to improve the facilitation of these interactions.

3. **Supporting infrastructure**. All of the support unit spaces, such as kitchens, washrooms, and server rooms, are in close proximity to the NOC secure area. This arrangement is conducive for prolonged operations by the NOC personnel.

Given the benefits of the existing infrastructure, the layout recommendations to the current layout are predominantly limited in nature without over-arching impacts to the entire NOC. The following areas of improvement were identified based on interviews with the operational community and an assessment of the current design by the HF team:

1. **Facilities for small team collaborations.** The NOC is currently being used by numerous teams for disparate objectives (e.g., multiple simultaneous incidents, congruent investigations and incidents). Moreover, larger response teams periodically warrant the need to carry on private discussions only involving a subset of team members. The current NOC layout is not conducive for small teams to easily congregate to carry on these types of interactions without causing disruptions to the larger population.

2. **Individual workstation design.** With the exception of the ACC and WOs, residents within the secure area of the NOC do not permanently inhabit a workstation. Depending on the nature of the incident and/or investigation, individuals will occupy a workstation for a select period of time. Regardless of the situation, the design of the workstation should allow for an individual to access the necessary systems and data repositories needed to execute their tasks without requiring them to shift between workstations (currently, certain applications are only available at designated workstations). With the exception of a few workstations with specific operator requirements (e.g., WOs and LOs), a standardized approach to workstation design coupled with system accessibility would provide flexibility in the utilization of a particular workstation by different roles. This is in contrast to restricting a workstation to a single role. Moreover, the ability for individuals to temporarily stow personal belongings when working in the NOC for extended periods of time would be beneficial.

In contrast to the majority of workstation in the Operations Area, the DO workstation necessitates its own specific requirements to accommodate the particular responsibilities inherent to this position. Based on interviews with a DO, the most notable requirement is for the workstation to provide the ability for two DOs to work simultaneously side-by-side without interfering with one another. As such, each DO requires a personal feed to the necessary systems (i.e., Flight Explorer, ROSS, Internet, Mandrake, CE). Currently, the workstation is limited to a single Internet feed which can cause time-sharing issues.

3. **Space availability in the ACC.** The amount of space allocated to the ACC unit space is not currently sufficient resulting in a series of drawbacks. With the exception of ROSS, there exists a single version of each network workstation. Having multiple versions of each system provides redundancy as well as the ability for parallel activity on the system. Due to the requirements for security separation

of classified systems, the current space allocation for the ACC does not provide further opportunity for growth to include additional systems as required. Furthermore, working conditions are 'cramped' when two individuals are working simultaneously on systems that are adjacent to one another. Finally, there is a lack of space for data archiving and storage. To that end, the ACC unit space could benefit from an increase in its footprint.

4. **Air Cell Layout.** Similar to the ACC, the allocation of space for Air Cell is not sufficient to effectively accommodate the number of individuals present in the Air Cell to address an air incident (upwards of eight). Furthermore, there lacks an efficient communication corridor between the Air Cell team and Operations Area. To address this bottleneck, a runner is employed by the team in order to facilitate communications between the two unit spaces.

5. **Response Scalability.** The current NOC configuration provides minimal capabilities to scale up or down (i.e., accommodate additional personnel) to address events of different magnitudes.

6. **Cleanliness.** Around the periphery of the NOC, there is miscellaneous equipment and stacks of paper that introduce clutter into the room. Removal of these items would increase the amount of free space and improve the overall presentation of the Operations Area to external interested personnel

Although not directly linked to the layout of the NOC, the following areas of improvement were also identified based on the HFE assessment:

7. **Records Management.** A long term capability for records management of special projects (i.e., no TSSI network management) does not currently exist. Any new capability that is implemented needs to have a search mechanism to facilitate data retrieval. Due to the lack of this data mining capability, team members have less time to perform the analysis part. On a related note, a central repository for all incoming information to the NOC also does not exist.

8. **Awareness of personnel.** In response to an unforeseen event and to activate the NOC, the required personnel need to be promptly notified and subsequently mobilized in short order. Currently, both of these activities are problematic due to the lack of awareness of the individual's current whereabouts coupled with an appreciation of the most suitable means by which to contact them (i.e., mobile number vs., home number).

9. **Activation levels.** Activation Level 1 represents the minimal manning that is typically in place to maintain routine day-to-day operations. At the other extreme, Activation Level 3 necessitates full manning in response to a major event. Both activation levels are typically well known; however, Activation Level 2 is generally unknown, or at least unclear. This level is not fully documented nor equally implemented due to the dependency on the nature of the event. Whether this is problematic remains unclear.

10. **Data classification.** There are multiple levels of classification for data being handled by NOC personnel. To the greatest extent possible, the layout of the NOC must take into consideration separation between secure and non-secure interactions. For example, on-going classified conversations occurring by personnel in the Operations Area may be compromised through dissemination via open telephones lines (e.g., DO communicates with external individuals via the national tip line which is located within the secure Operations Area).

11. **DEOC Counterpart.** Collaboration between the NOC and DEOC is required to manage and administer the incident response. However, NOC personnel are not always cognizant of their DEOC counterpart which can hamper timely collaboration between organizations.

12.**Business Continuity Plan.** Business continuity as it pertains to ensuring continued operations in the event that the NOC becomes compromised has not been fully defined and documented. For example, internal governance is lacking as it pertains to specifying ownership of systems, identifying the mission critical systems, and determining if a system is recoverable. Moreover, policies do not exist for the indoctrination of new technology within the NOC.

5   Design Options

5.1 General

At the time of conducting this design effort, the exact location of the future NOC at the new RCMP facility on Leikin Drive had not been finalized. The expectation was that this move would take place during 2013. Given this uncertainty, the scope of the design effort presented herein was limited to identifying layout improvements within the confinements of the existing NOC infrastructure located at the Vanier facility. To that end, upgrades to the layout where limited to those improvements that could be achieved in a relative short time frame taking into consideration fiscal constraints.

The following sections describe the design approach and present layout concepts that can be treated as a starting point for determining, through collaboration with RCMP stakeholders, a proposed layout for the existing NOC.

5.2 Design Approach

In addition to taking into consideration the layout requirements presented in Section 4, several design heuristics were applied explicitly to the design of the RCMP NOC. The following sections outline these heuristics which further provide rationale for the approach taken in developing layout concepts for the NOC.

5.2.1 Layout Configuration

While the layout of EOCs can take on many forms in order to suit its functional objectives, layouts can typically be characterized by four basic configurations (Gouin, 2009):

1. **Boardroom.** This configuration gathers personnel around a central table or an assembly of tables (e.g., horseshoe configuration) as a means to emphasize interaction and collaboration for a relatively small team composition (dozen or less). The natural locus of control is at the end of the table where an authoritative person would be seated (in the case of the NOC, this could be the Incident Director managing the CMT). Large screen displays, if any, are typically mounted at one end of the table behind the lead figure's seat (to reinforce their pronouncements) or at the opposite end of the table (to brief the lead figure). Additional staff generally sits in chairs along the walls, forming an outer ring facing inward toward the table. Smaller EOCs typically adopt the Boardroom layout.

2. **Mission Control.** Modeled after legacy technology-based C2 centers (e.g., military centers, missile launch control rooms, network control centers, etc.), this layout arranges individuals in rows facing a wall comprised of large visual displays. Staff interactions are mediated through a technological "knowledge-base" represented by these large screen displays. Moreover, despite staff seated in close proximity to one another, verbal communications are typically conducted via telephone, intercom or even e-mail rather than face-to-face. A layout of this nature is practical provided the tasks are technical in nature and the technical knowledge base is complete and current. It is not unusual for players to abandon their positions and reconvene in break-out rooms, for face-to-face problem-solving in response to a crisis.

3. **Markeplace**. A layout of this nature can be characterized by a series of small Boardroom-style tables scattered throughout a large space. Each grouping has a specialized function with the layout emphasizing close collaboration between members with a relatively unstructured and flexible

interaction style. A layout of this nature maintains a relatively high level of autonomy for each grouping.

4. **Bulls Eye.** The layout builds upon the Boardroom design with additional support staff support at tables arranged in concentric circles around the main table. Staff sections are seated behind their representatives at the main table. This model emphasizes the main-table players as representatives of large organizations. Consultation with staff is facilitated and the amount of staff support to the decision makers is increased.

The original NOC configuration followed a Mission Control style of layout with personnel arranged in rows facing an information wall comprised of four large screen displays (refer to Section 3.1.5). Modifications were made to improve collaboration between a subset of incident response members through the inclusion of two pod configurations—one for the Command functional groupings and another pod for the Information Officer. As such, the current NOC configuration is a hybrid combining characteristics from both the Mission Control and Marketplace layouts. As part of the design effort described herein, the HF team also leveraged the characteristics of these two styles for the following reasons:

1. The Marketplace style addresses the need to support multiple sub-group interactions that is conducive to the organizational structure and interaction style of the CMT; and

2. The Mission Control style appeals to the requirement for providing a working configuration for personnel that do not require continual interactions within others on the floor of the Operations Area, specifically data entry personnel and LOs.

Conversely, the HFE team did not investigate leveraging the characteristics of the remaining two styles for the following reasons:

1. The Boardroom style inherently lends itself to supporting a single, continual group discussion between team members. While this type of group interaction may be reflected in the administration of collective situation updates or for providing command direction, for instance, by the Incident Director to the CMT, these group exchanges are not frequent as part of the incident response by the NOC. Instead, the Operations, Planning, and Logistics functional grouping works somewhat autonomously with a primarily single linkage back to the Command staff via the respective Section Chiefs. As such, placing a large table in the middle of the Operations Area would provide minimal added value for supporting the team's overall interactions while occupying a significant amount of real-estate.

2. Given that the Bulls Eye style expands upon the Boardroom style, this option was not investigated as part of the NOC design effort due to similar reasons (i.e., group interactions do not typically have a single locus of attention and maximizing floor space within the Operations Area to accommodate additional workstations).

5.2.2 Design Constants

Concepts were explored with respect to improving the layout of the existing NOC. Regardless of the concept, the following areas of improvement were taken into consideration (in conjunction with the requirements presented in the previous section) based on feedback received from the operational community:

1. **Unit Spaces**. Within the secure area, the layout of the NOC will maintain the three primary functional areas segregated into separate unit spaces: ACC, Air Cell, and Operations Area.

2. **Infrastructure.** The existing infrastructure was   to remain intact to the greatest extent possible;

therefore, existing walls and doors were not to be altered.

3. **Functional Groupings.** Despite the potential for a larger number of NOC personnel in the Operations Area to address a given incident, the lines of communications for most individuals are predominantly limited to a subset of personnel on the floor (refer to link analysis in Section 3.3.1). To that end, there exist smaller teams in continual communication and collaboration for which the NOC layouts should support. These functional groupings and their membership are presented in

4. Table 11.

Table 11: NOC Functional Groupings

Grouping	Members
Command	Incident Director, Deputy Incident Director, Scribe
Operations/Tasking	Operations Section Chief, SMEs
Planning	Planning Section Chief, Document Management Unit, Major Case Management, Loggist,
Logistics	Logistics Section Chief, Legal, Risk Management
Linkages	LOs from external agencies and departments (i.e., DND, CSIS, CBSA, TC)

5. **Break-out Rooms**. Based on feedback from interviews with RCMP personnel, a common theme was the lack of easily accessible break-out rooms for private (classified) discussions and collaboration. These interactions may be short-term or long-term as in the case of on-going investigation/operation being handled by the JIG. Regardless, the intent of a break-out room would be to facilitate interactions between team members while limiting disruptions to the remaining personnel on the Operations Room floor. They also provide the means to segregate discussions in the event that the information is not privy (due to classification reasons, for instance) to all individuals present in the Operations Area.

6. **Surge Capacity.** The scalability of the current NOC is constrained by the footprint imposed by the legacy consoles. Based on past events and exercises, the NOC is required to accommodate additional personnel above and beyond the existing seated capacity. As such, the proposed design needs to improve the surge capability by providing additional workstations for individuals to work in the NOC.

7. **Workstation Design.** Occupation of the NOC workstations by personnel is not on a permanent basis. Workstations will be occupied by personnel for a length of time dictated by the incident, investigation, or operation. Given that the NOC workstations are not continually dedicated to a single individual, their design should be role independent so that any seated operator (regardless of assigned responsibilities) has access to the necessary systems to perform their day-to-day activities. This provides flexibility in the NOC layout to accommodate CMTs of varying composition.

5.3 Proposed Layout

Based on the abovementioned constraints and approach, concepts for the layout of the NOC were prototyped in the Autodesk 3ds Max software package for visualization and subsequent presentation to the RCMP NOC stakeholders for consideration. Figure 11 depicts a conceptual layout for the NOC with the majority of proposed changes reflected in the configuration of the Operations Area. The potential layout produced during the conduct of the present work provides the foundation for subsequent discussions that will refine the proposed layout into the optimal configuration.


Figure 11: Proposed NOC Layout Design

5.3.1 Operations Area

A proposed layout for the Operations Area unit space, as presented in Figure 12, adopts a hybrid of the Mission Control and Marketplace layout configurations. The primary layout changes and associated rationale is as follows:

1. **Functional Groupings.** To better accommodate the functional groupings within the Operations Areas, a series of pod configurations are recommended for the various sub-groups (i.e., Command, Planning, Operations, Logistics). The intent of these pod arrangements is to facilitate the frequent collaborative interactions between team members as defined by the link analysis (

2. Table 11). The current linear configurations are not conducive for these forms of interactions for these subgroups. The Operations pod was placed in the middle to facilitate communications with the entire row of LOs that report to Operations Section Chief.

The LOs and the secondary support functions (e.g., safety) were retained in a side-by-side arrangement

since their roles and interactions as part of incident response do not necessitate a pod configuration.

3. **Surge capacity**. The size of the proposed consoles for NOC layout has a smaller footprint than the existing consoles which provides the ability to increase the amount of available seating within the NOC. In turn, the proposed NOC layout can accommodate extra personnel (i.e., three additional workstations plus a break out room) in comparison to the current NOC configuration. (Note: larger consoles were not proposed since it was deemed that majority operators require two flat screen displays to perform their standard duties coupled with the requirement to increase the number of personnel within the upgraded Operations Area).

Figure 12: Operations Area

4. **Break-Out Room**. A break-out room within the Operations Area has also been proposed in order to easily convene smaller group interactions. The conference table could be equipped with communication 'drops' to allow individuals access their particular systems. The glass walls would enable individuals in the room to maintain a sense of awareness of activities in the rest of the room while affording privacy as required. To that end, this break-out room could be   employed by members of the CMT for ad-hoc discussions of short duration or by a sub-team (e.g.,   JIG) for prolonged investigations.   A door

providing dedicated access to the break-out room from the exterior has also been proposed as a means to reduce disturbances to the Operations Area when bringing personnel to and from this room. Further investigation is required to determine the security implications and requirements for inclusion of this access point.

Figure 13: Operations Area Breakout Room

5. **Duty Officers**. The DO consoles have been re-located off to the side of the Operations Area in order to accommodate the inclusion of the pod configurations. These workstations remain in close proximity to the Operations Area entrance in order to control access to this area of the NOC.

5.3.2 Air Cell

Proposed changes to the Air Cell were limited in nature. To that end the following upgrades were proposed:

1. The wall dividing the Air Cell and the main corridor could be pushed out by approximately 12 inches (Figure 14). Moving the wall in this manner would provide a relatively straightforward means by which to significant increase the amount of real-estate in this breakout room and therefore improving the collaboration environment for the Air Cell team.
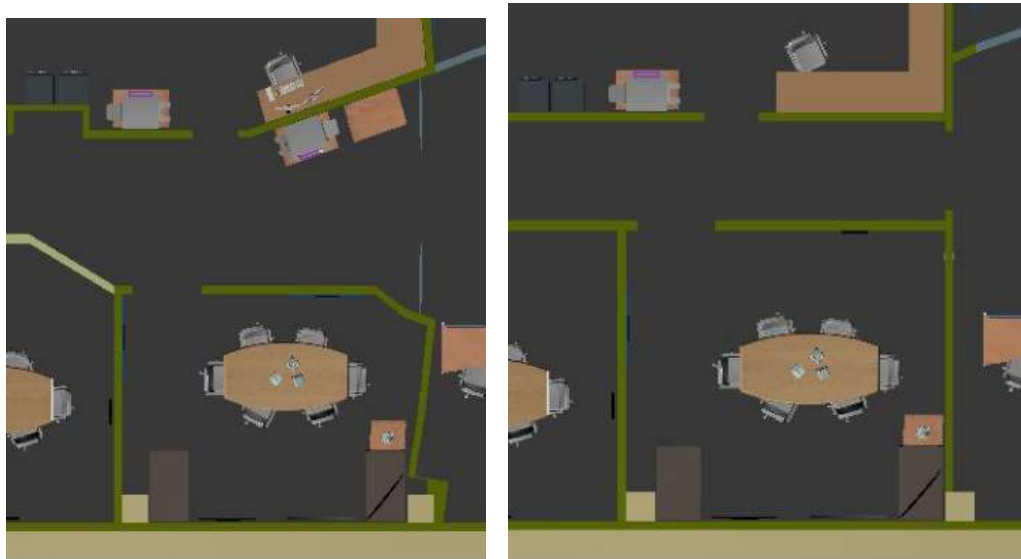
Figure 14: Air Cell – Existing vs. Proposed

2. To improve the collaborative interactions between the Operations Area and the Air Cell, the inclusion of a more direct passageway between the two unite spaces, as depicted in Figure 15, would help to better facilitate the exchange of information.

Figure 15: Air Cell/Operation Area Passageway

5.3.3 Administrative Communications Centre

Similar to the Air Cell, the ACC real-estate could be   increased by 'straightening' the outer wall adjacent to

the corridor as proposed in Figure 16. This change would also involve removing the seldom used personal cubbies aligning the outer wall in close proximity to the main entrance to the NOC.

Another option to increase the ACC would be to occupy the real-estate adjacent to the Air Cell. This space could be used to house the unclassified systems and thereby providing space to include additional classified systems as required. Utilization of this space in this manner requires further discussions with the stakeholders.
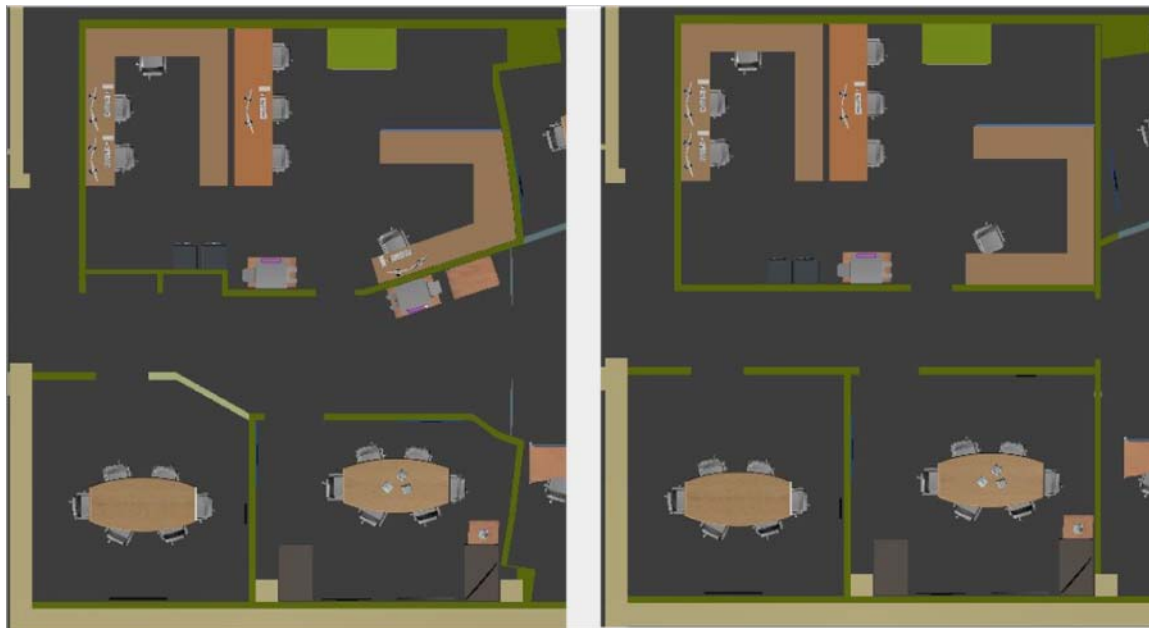
Figure 16: ACC – Existing vs. Proposed

5.3.4 Alternate Configuration

The aforementioned layout represents a single option for re-arranging the configuration of the Operations Area to improve the ability of the CMT to satisfy their objectives. As such this layout represents a starting point for discussions with the RCMP stakeholders for subsequent refinement of the layout.

As an alternate configuration, the Command pod could be re-located to the location of break-out room, as depicted in Figure 17, and segregated from the remaining Operations Area with a half glass wall. This arrangement would increase the space between the Operations, Planning, and Logistics pods while providing the Command pod with more privacy.

Figure 17: Optional Configuration

More elaborate layout configurations could be explored by the HF team (e.g., sliding walls to divide the Operations Area in order to support multiple simultaneous response teams); however, these concepts would require consultation with the RCMP stakeholder to determine their feasibility prior to further investigation.

5.4 Link Analysis

5.4.1 Overview

Link analysis is a systematic technique to visually represent the interactions (i.e., visual, auditory, physical and movement) between the components of the system (i.e., operators, workstations, and equipment), so that the following characteristics of any given workspace layout can be identified:

1. Bottlenecks within tasks or processes;

2. Workflow inefficiencies; and,

3. Issues that may interfere with successful tasks/process completion.

5.4.2 Methodology

The following steps were required for the application of link analysis to the proposed Operations Area layout:

1. Develop and validate link tables. Link tables describe the importance of all visual and auditory links between the components of the Operations Room.   These tables are presented in Section 3.3.1 as part of the analysis effort

12. Identify personnel functional groupings. These groupings were identified as part of the Mission Analysis effort; and

13. Analyze the auditory and visual communication links and generic physical tasks identified using Microsoft Visio. The HFE team performed a link analysis for each crewmember taking into consideration all functional groupings of the Ops Room personnel as identified in Section C.3.4 and the communication and interaction links identified in Section C.3.5. Visual and auditory links based on importance levels (high, medium and low) for all crewmember and equipment interactions were visually represented using Microsoft Visio and evaluated in terms of:

a. The distance between the information sender and receiver was appropriate for effective visual and auditory communication;

◆ The orientation of between crewmembers, or a crewmember and his/her equipment was appropriate for effective interaction; and,

◆ The presence of communication distractions or interruptions (e.g., distracting other operators or blocking an operator-equipment interaction).

5.4.3 Results

The following link analyses are depicted in the remainder of this section:

1. Communication links for the Command functional grouping (Figure 18);

2. Communication links for the Logistics functional grouping (Figure 19);

3. Communication links for the Operations functional grouping (Figure 20); and

4. Communication links for the Planning functional grouping (Figure 21).

To illustrate the 'worst case scenario', these figures represent the communication links between the CMT personnel required to respond to a major event or crisis (i.e., Activation Level 3). It should be noted, that implementing a client-server infrastructure in the NOC would provide flexibility in optimizing the communication links for this type of scenario. Personnel could work effectively irrespective of their physical location since access would be provided to their systems (the LOs would be exception since they operate on dedicated external systems). As such, a preferred seating arrangement (with the exception of the LOs) can be instituted depending on the activation level and the specific resources (e.g., SMEs) required to support the incident response. To that end, a specific seating arrangement was not proposed for the front row personnel.

The link analysis of the proposed Operations Area layout of the NOC demonstrated that the functional teams are grouped together well insofar as team members are located within close visual and auditory proximity. Minimizing these distances allows operators to get the required information quickly, without enhancing their voices and without any distraction to other operators. For example, the Incident Commander and Deputy Incident Commander are well positioned to interact with the Section Chiefs (Planning, Operations, and Logistics).

Figure 18: Communication Links – Command Functional Grouping

Figure 19: Communication Links – Logistics Functional Grouping

Figure 20: Communication Links – Operations Functional Grouping
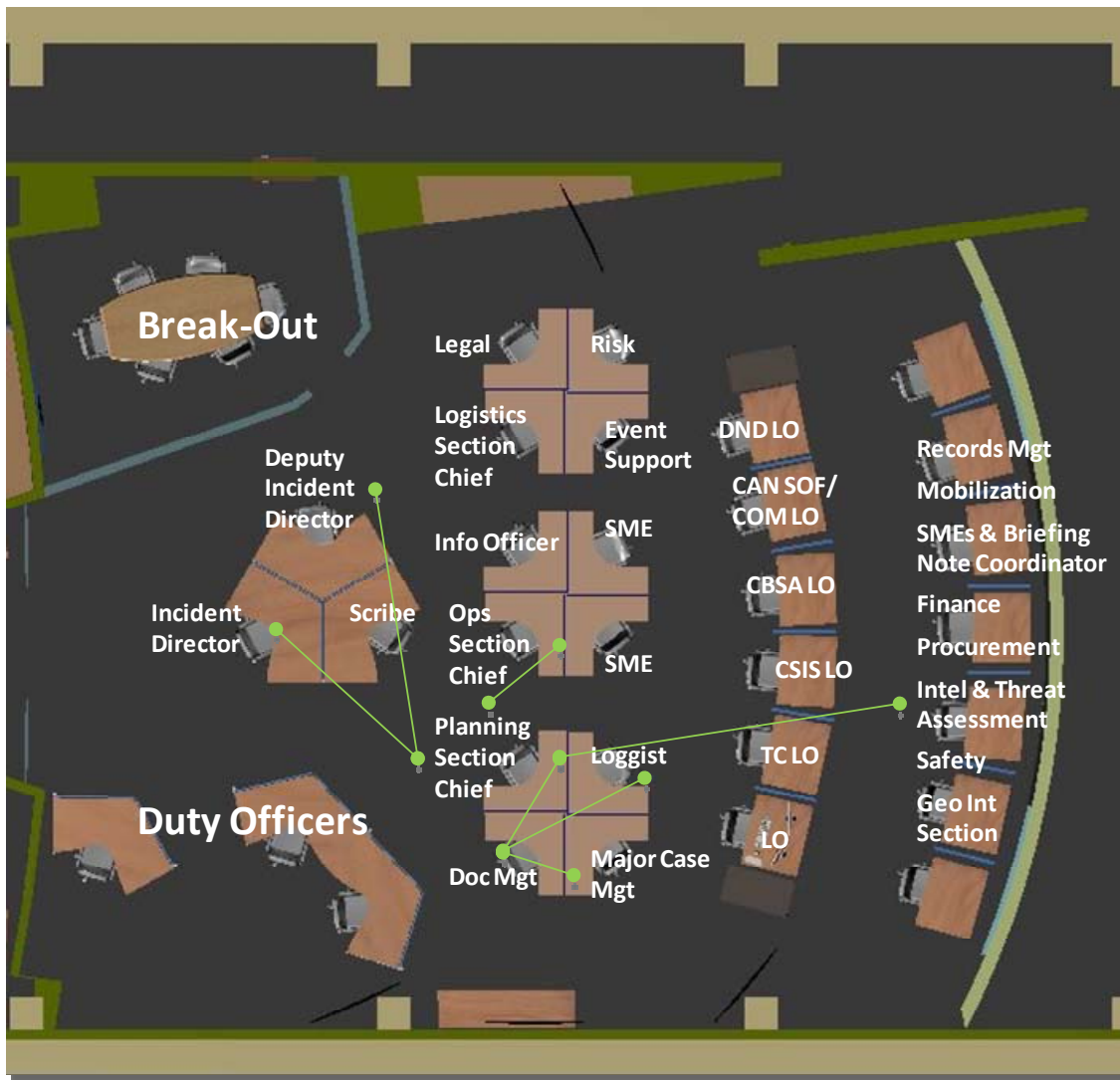
Figure 21: Communication Links – Planning Functional Grouping

5.5 Anthropometric Assessment

5.5.1 Overview

Computer Aided Design (CAD) Mannequin Analysis was used to conduct evaluations of requirements relating to operator sightlines, clearance and reach to the personnel, consoles and ancillary equipment within the Ops Room. This type of analysis allows the use of virtual human mannequins that are physically representative of the range of anticipated Ops Room personnel (i.e., 5th percentile female to 95th percentile male). The use of CAD Mannequin Analysis tools, in this case HumanCAD, allow the rapid and precise evaluation of operator reach, sightlines and access to the personnel, consoles and ancillary equipment within the Ops Room.

5.5.2 Approach

A human-form mannequin analysis of the NOC layout was conducted to further assess the compatibility of the proposed arrangement with operator characteristics, the task requirements, and the environment. Specifically, the layout was evaluated based on the derived requirements captured in Section 4 using the following approach:

1. A 3-D model of the operations area was developed by the HFE team within the Autodesk 3ds max modelling environment to facilitate visualization. Fully rendered models, including auxiliary equipment, were made available within a user-controlled application structure to facilitate free movement within the modelled space, to support the review process. The model was developed as required to ensure it incorporates the requisite elements to evaluate the associated layout criteria.

14. The 3ds max model was then transferred to the HumanCAD modelling environment so that human mannequins could be exercised within the 3-D model of the Operations Area. Specifically, the HFE team conducted operator workspace configuration evaluations to assess the gross physical aspects of the system interior with respect to safety, and task performance, according to the following design factors, where possible,:

a. Compatibility with user characteristics including anthropometric accommodation, reach distances, and lines of sight;

b. Internal and external vision requirements as defined by the task analysis; and

c. Communication requirements, as derived from the task analysis.

5.5.3 Results

For the proposed layout, the anthropometric findings focused on two areas of interest: passageways and visual sightlines. Additional evaluations of this nature should be performed as part of the workstation design effort to ensure proposed solutions satisfy the range of potential operator anthropometric profiles.

5.5.3.1   Passageways

While passageways were designed to satisfy widths as defined in HF standards, such s MIL-HDBK-759 (Department of Defence, 1995), Figure 22 further illustrates compliance of the proposed layout to these specifications. Of note, the passageway between the curved LO row and the Planning functional grouping was targeted as an area of interest.
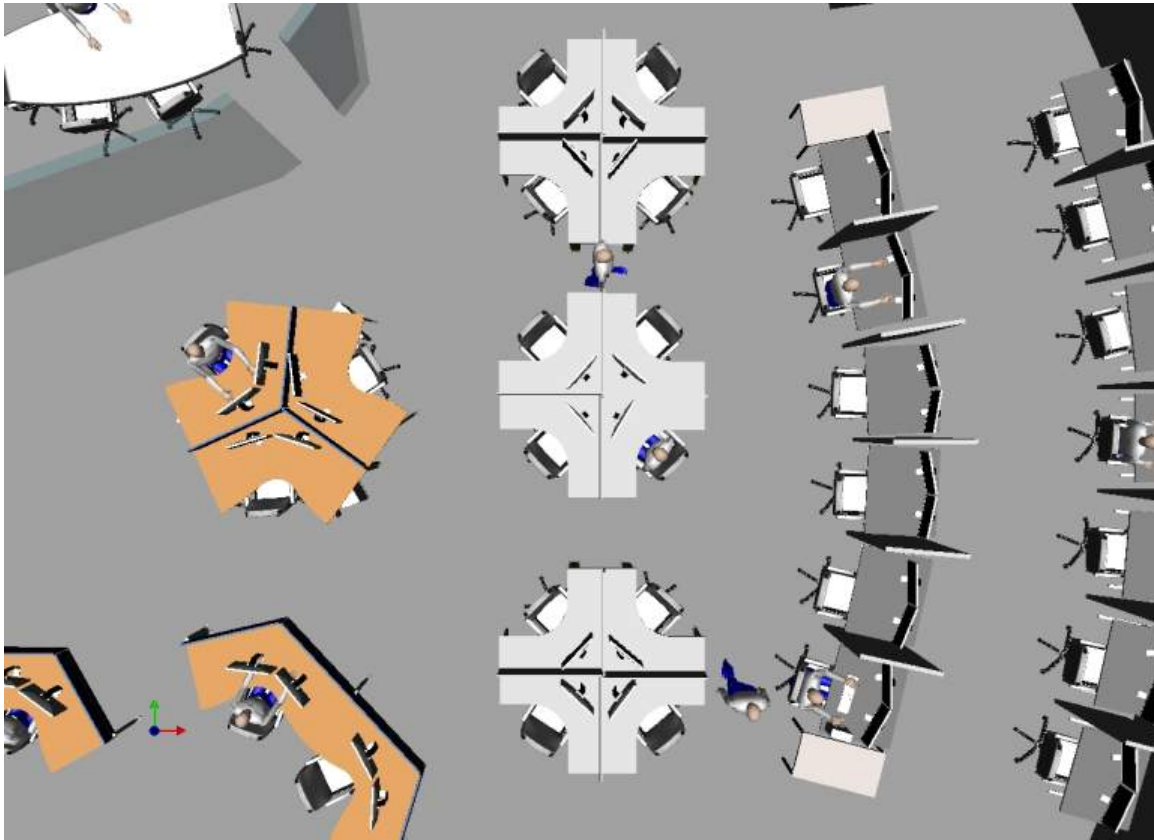
Figure 22: Top View - Passageways

5.5.3.2   Sightlines

Visibility of the information wall as well as sightlines between personnel was another area of interest with respect to the anthropometric assessment. The objective is to ensure that operators seated at their consoles still have visual access to the large screen displays at the front of the room as well as unobstructed sightlines to other seated personnel. To that end, the following three sightlines were generated to illustrate compliance to the aforementioned criteria:

1. Incident Director seated at the Command Pod (Figure 23);

2. Duty Officer seated at console (Figure 24); and

3. An individual seated in the proposed break-out room (Figure 25).
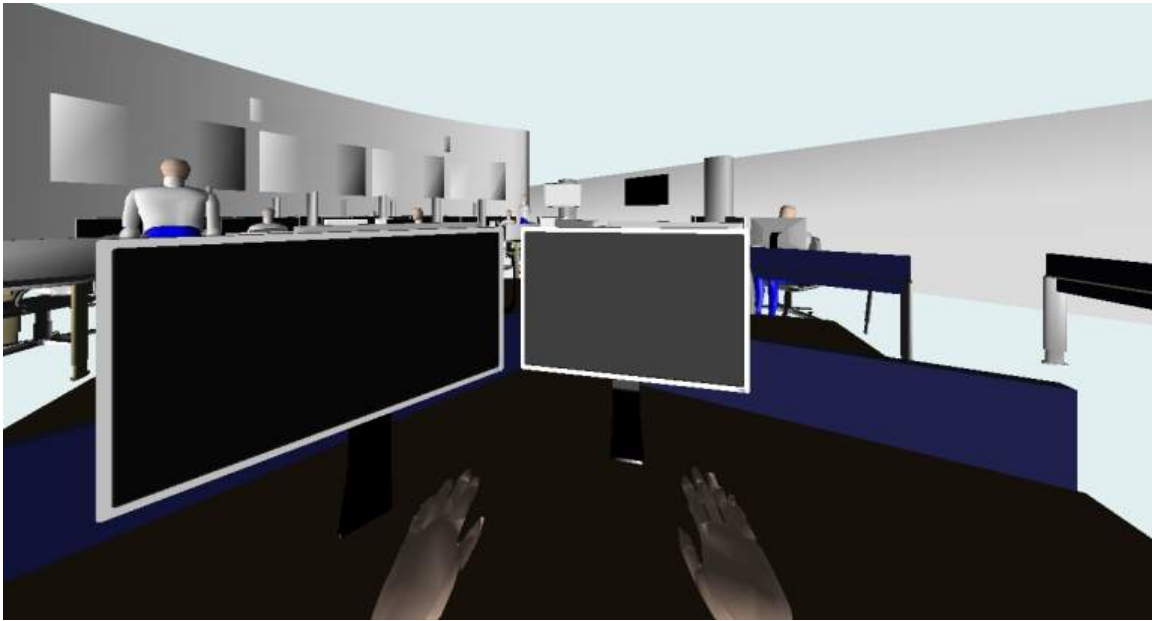
Figure 23: Seated Incident Commander Sightline
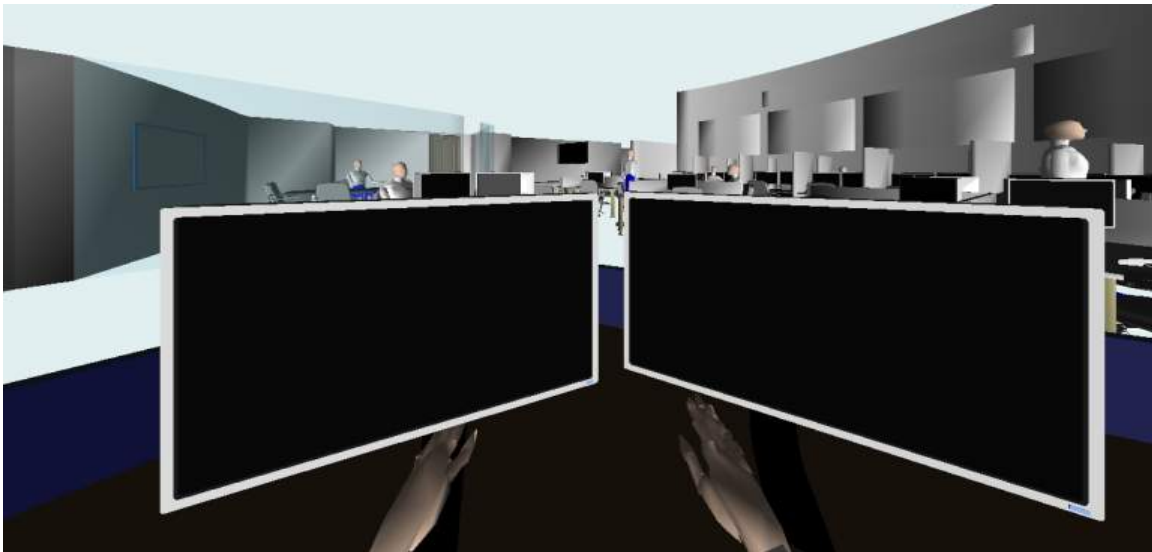
*Figure 24: Seated Duty Officer Sightline*
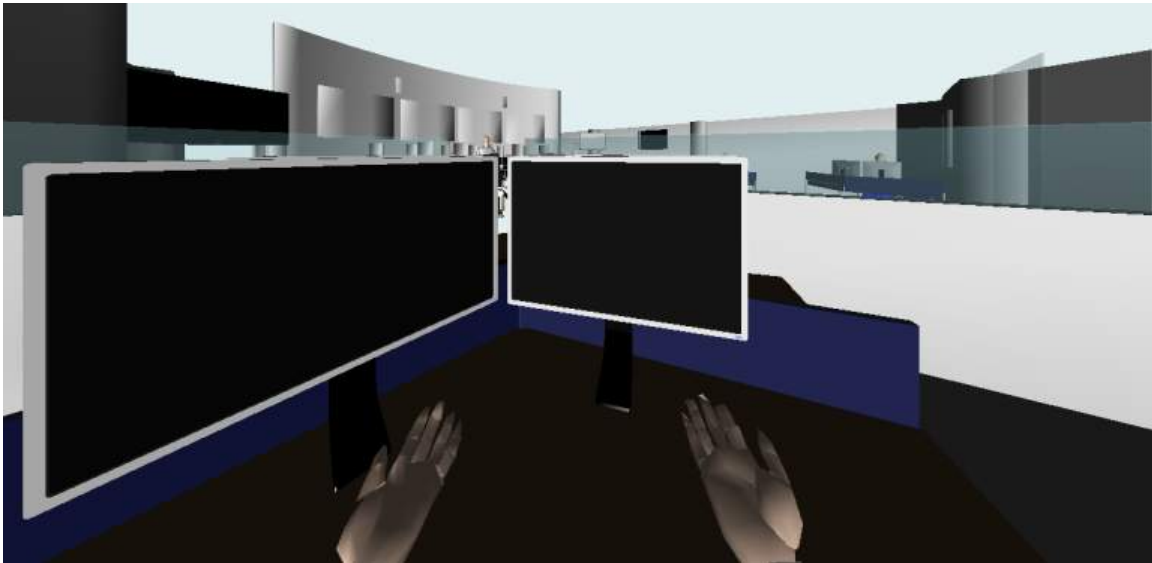
Figure 25: Seated Operator in Break-Out Room Sightline

6   Results and Recommendations

6.1 General

The objective of this research documented herein is four-fold:

1. To understand the purpose of the NOC and its role in fulfilling RCMP's mandate;

2. To identify the roles and responsibilities of the personnel of the NOC personnel and their information exchange requirements;

3. To define a series of HFE requirements and criteria to inform the design effort and provide supporting rationale, and

4. To deliver concepts for the physical layout of the existing NOC to maximize the effectiveness of the NOC's capability for emergency management in the short-term and long-term timeframes.

The following sections provide a high-level overview of the results stemming from this research effort as well as recommendations for subsequent areas of investigation.

6.2 Results

The intent of the effort documented herein was to investigate potential options for improving the layout of the NOC within the constraints of the existing infrastructure. To that end, the following results stem from this exercise:

1. The HGA provides an effective means to capture and communicate the objectives and the user requirements associated with the NOC without being constrained to a specific means(i.e., people, processes, technology, infrastructure) by which they are achieved. As such, the analytical findings are not restricted to the current NOC layout.

2. The existing infrastructure that physically segregates the secure area into three primary unit spaces (Operations Area, ACC, and Air Cell). Each of these physical unit spaces is also associated with a unique set of functional requirements. This differentiation provides a suitable starting point and 'sandbox' by which new design options can be investigated. To that end, the options investigated were constrained with the existing walls remaining primarily intact.

3. Communication and collaboration in the current NOC could be improved by implementing a series of fundamental changes to the physical configuration of the NOC primarily the following:

a. Arrangement of CMT sub-teams into pod configurations;

b. Inclusion of a break-out room in the Operations Area; and

c. Increasing the ACC and Air Cell footprint by reducing the width of the entranceway.

6.3 Recommendations

The analysis and findings presented herein are a first step in the process and provide a means to spawn further discussion and subsequent investigation (as required) pertaining to the re-design of the current NOC layout. Based on the analysis conducted to date and as a way forward, the following next steps are recommended:

1. The timing of this preliminary design effort was hampered by a turnover in personnel as well as key personnel being seconded on special assignment during the summer months. Further engagement with the RCMP stakeholders should be sought in order to validate the analytical findings that were identified during the conduct of the work. This feedback should be incorporated within the proposed design and documented to ensure the traceability between the stakeholder feedback and the refinements to the existing layout of the NOC.

The following layout-related issues should be resolved prior to continuing the design effort:

a. Inclusion of a break-out room within the secure area of the NOC;

b. Use of the space adjacent to the Air Cell for a break-out room or as additional space for the ACC (e.g., to house the non-secure systems); and

c. Implementation of a client-server capability to reduce space demands in the Operations Area as well as provide improve flexibility in seating arrangements.

15. The current layout of the NOC is equipped with a series of large screen displays. Utilization of these screens would benefit from additional analyses to identify the information requirements for the NOC occupants and how this information should be presented within the facility to support the goals of the CMT.

16. A series of options for console designs should be investigated based on both functional requirements of the operator as well as the HFE guidelines stipulated in Section 4. Specifically:

a. Given that the NOC workstations are not continually dedicated to a single individual, their design should be role independent so that any seated operator (regardless of assigned responsibilities) has access to the necessary systems and networks to perform their day-to-day activities. This provides flexibility in the NOC layout to accommodate CMTs of varying composition. The exception would be the LOs that require access to dedicated networks.

b. The Bridge design needs to better accommodate both DOs working in close proximity without interfering with another. This requires both DOs to have their own feeds to networks and systems, such as the Internet. Moreover, the DOs also require access to both the network switching for selecting the feeds being presented on the large screen displays and the national security tip line.

To ensure the NOC workstations comply with these guidelines, a formal HFE evaluation of the proposed console design options are recommended. Based on the analytical findings the HFE team can assist with the definition of requirements and/or identification of suitable options prior to procurement.

17. The existing NOC has significant clutter that could be minimized or eliminated in order to improve the overall visual appeal of the area as well as to increase the footprint of the workable space. Moving forward, the NOC should investigate instilling a 'Clean Office' policy to maintain the professional standards of this area. For example, the Ottawa Paramedic Services (OPS) implement a policy of

this nature as a means to, for example, restrict consumption of food in Operations Area during normal day-to-day operations. The results are an Operations Center that personnel find extremely conducive for working and that the OPS is proud to present to external interested parties and does not require additional effort to prepare for guest visits.

18.This initial analysis of the NOC organization was aimed at defining the physical layout of this operations center that would satisfy the criteria and requirements associated with the identified roles and responsibilities that are held within this organization.   As the roles, responsibilities and operator requirements are dependent upon the mandate of the NOC rather than the location in which the NOC resides, the methodology and analytical findings can be applied to support the physical layout design for the new NOC location that is proposed for Leikin Drive as part of the RCMP re-location to this new facility.

19.Activation Level 1 represents the minimal manning that is typically in place to maintain routine day-to-day operations. At the other extreme, Activation Level 3 necessitates full manning in response to a major event. Both activation levels are typically well known; however, Activation Level 2 is generally unknown, or at least unclear. This level is not fully documented nor equally implemented due to the dependency on the nature of the event. Fully documenting each of the activation levels will help to provide additional structure to the issue. Subsequent analyses of this nature should be performed.

20.The activation of the NOC, in response to an unforeseen event is enabled through (a) the prompt notification of the required personnel and (b) their subsequent and rapid mobilization. Currently, both of these activities are problematic due to the lack of awareness of the individual's current whereabouts coupled with an appreciation of the most suitable means by which to contact them (i.e., mobile number vs., home number). Providing a more amenable means of remaining aware of plausible personnel locations as well as the best means by which to contact them would be extremely beneficial in order to streamline the activation process.

21.A long term capability for records management of special projects (i.e., no TSSI network management) does not currently exist. Any new capability that is implemented needs to have a search mechanism to facilitate data retrieval. Due to the lack of this data mining capability, team members have less time to perform the analytical component. On a related note, a central repository for all incoming information to the NOC is also not currently implemented. Addressing issues related to record management would facilitate the processes associated with storing, retrieving and analysis of the records leading to enhancements in both knowledge and understanding.

22.There are multiple levels of classification for data being handled by NOC personnel. To the greatest extent possible, the layout of the NOC must take into consideration separation between secure and non-secure interactions. For example, on-going classified conversations occurring by personnel in the Operations Area may be compromised through dissemination via open telephones lines (e.g., DO communicates with external individuals via the national tip line which is located within the secure Operations Area). Means for segregating these interactions should be further investigated.

23.Business continuity as it pertains to ensuring continued operations in the event that the NOC becomes compromised has not been fully defined and documented. For example, internal governance is lacking as it pertains to specifying ownership of systems, identifying the mission critical systems, and determining if a system is recoverable. Moreover, policies do not exist for the indoctrination of new technology within the NOC. A business continuity plan should be developed in order to ensure (a) uninterrupted operation of the NOC capability should the primary NOC facility be compromised and (b) that the NOC will be capable of performing its national role during the conduct of a   major event or incident even if an event internal

to the RCMP (e.g., pandemic, train derailment, etc) causes the organization to work under compromised conditions.

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8 Acronyms and Abbreviations

ACC..Administrative Communications Center
AFCCIS ....Air Force Command and Control Information System
C2 ....Command and Control
CAE PS.................................CAE Professional Services, CAE Professional Services, CAE Professional Services
CBSA..Canada Border Services Agency
CFACC ....Canadian Forces Aerospace Command Component
CMT ....Crisis Management Team
COI..Contact of Interest
COP ....Common Operating Picture
CSIS...Canadian Security Intelligence Service
CSNI..Consolidated Secret Network Infrastructure
CSS......................................Centre for Security Science, Centre for Security Science, Centre for Security Science
DEOC ....Division Emergency Operations Center
DFAIT .... Department of Foreign Affairs and International Trade
DND .... Department of National Defence
DNDAF ....Department of National Defence Architecture Framework
DRDC...........Defence Research and Development Canada, Defence Research and Development Canada, Defence
    Research and Development Canada
DWAN..Defence Wide Area Network
EOC............................Emergency Operation Center, Emergency Operation Center, Emergency Operation Center
GOC..Government of Canada
HFE ....Human Factors Engineering, Human Factors Engineering, Human Factors Engineering, Human Factors
    Engineering
HGA ....Hierarchical Goal Analysis
HVAC..Heating, Ventilation, and Air Conditioning
ICS...Incident Command System
JIG ....Joint Intelligence Group
LO..Liaison Officer
MCOIN...Maritime Command Operational Information System
NGO ....Non-Government Organization
NOC......................................National Operations Center, National Operations Center, National Operations Center
OGD ....Other Government Department
OPS...Ottawa Paramedic Services
PCO ....Privy Council Office
PET...People-Environment-Task
PMO ....Prime Minister's Office
RCMP...........Royal Canadian Mounted Police, Royal Canadian Mounted Police, Royal Canadian Mounted Police
SA...Situation Awareness
SME...Subject Matter Experts
TC...Transport Canada
TSA ....Team Situation Awareness
UDLC ....Universal Data Link Control
UFC ....United Facilities Criteria

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The Centre for Security Science (CSS) is a joint endeavour between Defence Research and Development Canada (DRDC) and Public Safety Canada to provide science & technology services support to address national public safety and security objectives (Defence Research and Development Canada, 2010). In June 2010 the former Director of the National Operations Center (Gerry Doucet) requested support from CSS to *"perform a comprehensive review of our national operations centre... maximizing our current centre and also looking at suggestions for a new one"* (17 June 2010).   In response to this request CSS contracted CAE Professional Services (CAE PS) to provide expert advice to its customers by applying Human Factors Engineering (HFE) methodology to a wide variety of organizational and functional problems. By identifying the enabling technologies, processes and personnel requirements that are necessary for an organization to achieve its mission, the HFE process will clearly show the most important area of concern for an organization.

The successful approach applied to municipal Emergency Operation Centers (EOCs) was applied for this research into the operations of the National Operations Center (NOC) for the Royal Canadian Mounted Police (RCMP).

The objective of this research was:

1. To understand the purpose of the NOC and its role in fulfilling the RCMP's mandate;

2. To identify the roles and responsibilities of the NOC personnel and their information exchange requirements;

3. To define a series of HFE requirements and criteria to inform the design effort and provide supporting rationale, and

4. To deliver concepts for the physical layout of the existing NOC to maximize the effectiveness of the NOC's capability for emergency management in the short-term and long-term timeframes. The layout produced during the conduct of the present work provides the foundation for subsequent discussions that will refine the proposed layout into the optimal configuration.

Le Centre des sciences pour la sécurité (CSS) a été mis sur pied en collaboration avec Recherche et développement pour la défense Canada (RDDC) et Sécurité publique Canada afin de fournir des services et du soutien en matière de sciences et technologie pour appuyer les objectifs nationaux relatifs à la sûreté et à la sécurité publiques (Recherche et développement Canada, 2010). En juin 2010, l'ancien directeur du Centre national des opérations (Gerry Doucet) a demandé le soutien du CSS afin *« d'effectuer un examen complet du Centre national des opérations (...) afin de maximiser le rendement de ce dernier et prendre connaissance des suggestions visant un nouveau centre »* (17 juin 2012). En réponse à cette demande, les dirigeants du CSS ont conclu un marché avec CAE Services professionnels (CAE SP). Ce dernier offrira des conseils d'expert aux clients en utilisant la méthodologie de l'ingénierie des facteurs humains à un vaste éventail de problèmes organisationnels et fonctionnels. En identifiant les technologies habilitantes, les processus et les besoins en personnel qui sont nécessaires pour que l'organisation remplisse sa mission, le processus d'ingénierie des facteurs humains permettra de montrer clairement le secteur de préoccupation le plus important d'une organisation.

L'approche efficace utilisée pour les centres des opérations d'urgence (COU) a été appliquée dans le cadre de cette recherche sur le Centre national des opérations (CNO) pour la Gendarmerie royale du Canada (GRC).

Les objectifs de la recherche étaient :
1.Comprendre la mission du CNO et le rôle qu'il joue pour remplir le mandat de la GRC;
2.Identifier les rôles et responsabilités du personnel du CNO et les besoins en matière d'échange d'information;
3.Définir une série d'exigences liées à l'ingénierie des facteurs humains et les critères pour orienter la conception et fournir une justification à l'appui;
4. Élaborer des concepts en vue de l'aménagement physique du CNO existant afin de maximiser l'efficacité de sa capacité de gestion des urgences à court et à long terme. L'aménagement conçu dans le cadre du travail actuel fournit le fondement des discussions à venir qui permettront de peaufiner l'aménagement proposé en vue d'obtenir la configuration optimale.